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UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN JOSE DIVISION

CELGARD, LLC,

PLAINTIFF,

V.

SHENZHEN SENIOR TECHNOLOGY MATERIAL CO. LTD. (US) RESEARCH INSTITUTE, AND SHENZHEN SENIOR TECHNOLOGY MATERIAL CO. LTD.,

DEFENDANTS.

Case No. 5:19-cv-5784

COMPLAINT FOR:

1. **PATENT INFRINGEMENT IN VIOLATION OF 35 U.S.C. § 271(A-C)**
2. **MISAPPROPRIATION OF TRADE SECRETS IN VIOLATION OF 18 U.S.C. § 1836 *et seq.***
3. **MISAPPROPRIATION OF TRADE SECRETS IN VIOLATION OF CAL. CIV. CODE § 3426 *et seq.***
4. **VIOLATION OF CAL. BUS & PROF. CODE § 17200**
5. **INDUCING BREACH OF CONTRACT**

6. **INTENTIONAL INTERFERENCE WITH PROSPECTIVE ECONOMIC RELATIONS**

DEMAND FOR JURY TRIAL

Plaintiff Celgard, LLC ("Celgard") files this Complaint against Defendants Shenzhen Senior Technology Material Co. Ltd. (US) Research Institute, and Shenzhen Senior Technology Material Co. Ltd. (collectively, "Defendants" or "Senior") and alleges as follows:

INTRODUCTION

1. This lawsuit concerns the brazen theft of Celgard's trade secrets and infringement of Celgard's patents by Senior.

2. Celgard, a U.S. manufacturer, located in Charlotte, North Carolina, has invested hundreds of millions of dollars into research and development for new battery technologies and is an innovator in both coated and uncoated separators used in lithium-ion batteries. Through years of investment, Celgard has worked hard to become a global leader in the development and manufacture of separators used in lithium-ion batteries for consumer electronic ("CE") devices and electric vehicles ("EVs"). Celgard makes products in North Carolina and ships them globally.

3. In the past 20 years, rechargeable lithium-ion batteries became very popular for use in varying applications. Lithium-ion batteries provide a power source with a higher energy density, longer cycle life, and higher operational voltages with a relatively small size and light weight, as compared to other rechargeable batteries. Separators are thin electrically insulating sheets used in batteries, and they sit between a battery's electrodes—the anode and the cathode. The separator is typically microporous to allow for ionic conduction (of lithium ions) while preventing direct physical contact and electrical connection between the electrodes of the battery. Separators are critical because the touching of the two electrodes typically results in a major electrical "short" of the cell and possibly in catastrophic failure such as fire or explosion.

4. Celgard has a broad portfolio of highly engineered products used in this industry and is one of the largest suppliers of separators to the lithium-ion battery industry. Celgard's separators are widely used in lithium-ion batteries for EVs, energy storage systems, power tools,

and CE devices, such as notebook computers, mobile telephones, and tablets. EVs include both hybrid EVs, like the Toyota Prius, and full-EVs like Teslas.

5. Celgard's work in the lithium-ion battery industry has been highly praised, and Celgard has received numerous accolades for its work in the lithium-ion battery industry. Celgard's work in EVs in particular has been praised by numerous high-ranking officials, including former President Obama, former Secretary of Energy, Steven Chu, and former Secretary of Labor, Hilda Solis.

6. Celgard has diligently pursued and procured intellectual property rights both in the United States and internationally. Celgard owns more than 200 United States and international patents. Celgard invented a new separator for use in batteries and patented its inventions in United States Reissued Patent RE47,520, (the "'520 patent"), formerly United States Patent 6,432,586, entitled "Separator for a High Energy Rechargeable Lithium Battery." The '520 patent describes and claims a separator for a high-energy rechargeable lithium battery that addresses the significant problem of dendrite growth (irregular growth of lithium metal when it is plated onto an electrode during the charging of a battery between electrodes), as well as other problems. The '520 patent is recognized as being foundational in the separator field and has been cited in over 50 patents and patent applications; it will expire in April 2020. Celgard also owns United States Patent No. 6,692,867 ("the '867 patent"), entitled "Battery Separator-Pin Removal" that is asserted in this action (collectively, the '520 patent and the '867 patent make up "the Asserted Patents"). A true and correct copy of the '520 patent is attached hereto as **Exhibit A**. A true and correct copy of the '867 patent is attached hereto as **Exhibit B**.

7. Celgard's commitment to innovation led it to develop numerous, cutting-edge technologies related to the design and production of separators in lithium-ion batteries. In addition to seeking patent protection on some of this innovative technology, Celgard also maintains other information as confidential and subject to trade secrets. The trade secrets and confidential information at issue in this dispute fall into at least one of these following categories: (1) Research and Development; (2) Procurement; (3) Manufacturing Processes and Systems; (4) Assembly; (5) Quality Control and Testing; and (6) Sales/Business.

8. Celgard has invested hundreds of millions of dollars to develop its trade secrets and confidential information over the course of 30 plus years. This significant investment has resulted in separators used in lithium-ion batteries that are safe and efficient and have evolved through vigorous testing and optimization with custom machinery and proprietary processes. As a result of its significant investments in developing its intellectual property, Celgard has become one of the top suppliers of separators for lithium-ion batteries in the world.

9. Senior, a Chinese manufacturer of separators, has avoided the time-consuming and expensive process of developing its own separator technology.

10. Senior embarked on a scheme to significantly injure Celgard and take over the global separator market with an intent to eclipse Celgard. Senior's strategy was not based on fair competition, independent research and development, and its own advances in technology. Instead, Senior's strategy was to build a suite of products through unlawful theft and use of Celgard's intellectual property, confidential information, and trade secrets. As a result, per public market reports, Senior became a top producer of separators in 2017, occupying 7% of the global market–matching Celgard.

11. Senior accomplished its scheme by, among other things, in October, 2016 hiring one of Celgard's lead scientists, Dr. Xiaomin (Steven) Zhang, who was an expert on separator membranes, resins, and production and had access to Celgard's most critical trade secrets and confidential information. Before leaving Celgard, Dr. Steven Zhang had access to, and accessed numerous Celgard trade secrets and confidential information. And when he joined Senior, Dr. Steven Zhang assumed a pseudo-name in China, Dr. Bin Wang, CTO of Senior, so that Celgard would not be able to locate him.

12. Celgard believes that Senior targeted Dr. Steven Zhang, who was involved in core aspects of Celgard's technology and business, to leave Celgard, take a competing position with Senior, and disclose and use Celgard's trade secrets and confidential information for Senior's benefit. Celgard believes Senior did this knowing that Dr. Steven Zhang was bound to a confidentiality agreement with non-solicitation clauses.

13. While at Senior, Dr. Steven Zhang has used and continues to use Celgard's intellectual property, including Celgard's trade secrets and confidential information, to help Senior create infringing separators. In fact, after Dr. Zhang joined Senior, a key property of Senior's separators was optimized. Dr. Zhang had access to this critical trade secret and confidential information at Celgard and unlawfully used and disclosed this information to Senior. Senior has incorporated Celgard's extremely valuable trade secrets and confidential information on at least its resin technology and dry process technology, which it gained through Dr. Steven Zhang.

14. Senior is using Celgard's trade secrets and confidential information to design, develop, and produce many of its separators and, in the process, has taken away important customers from Celgard. Recently, Senior acquired a multi-million dollar contract with one of Celgard's customers. Celgard has suffered and will continue to suffer great harm if Senior is allowed to continue using Celgard's trade secrets and confidential information and to continue infringing Celgard's patents.

15. Senior's misappropriation of Celgard's trade secrets and confidential information threatens Celgard's reputation as an innovator in the lithium-ion battery market and its market share that Celgard worked so hard to obtain. Through its development and protection of its intellectual property, including its patented technologies, trade secrets and confidential information, Celgard has diligently worked to become an industry leader of separators used in lithium-ion batteries. Senior's Chinese production of infringing separators through use of Celgard's patented technologies and misappropriating Celgard's trade secrets and confidential information is irreparably harming Celgard and will continue to do so if not enjoined.

THE PARTIES

16. Celgard is a limited liability company organized and existing under the laws of Delaware, with its principal place of business located in Charlotte, North Carolina. Celgard is directly owned by Polypore International, LP, which is headquartered in Charlotte, North Carolina, and is indirectly owned by Asahi Kasei Corporation, which is headquartered in Japan.

17. Celgard is a U.S. manufacturer, has a broad portfolio of highly engineered products used in the battery industry, and is one of the largest suppliers of separators to the lithium-ion battery industry. Celgard has grown to be a global leader in the development and production of specialty microporous membranes, including separators used in rechargeable or secondary lithium-ion batteries for CE devices and EVs.

18. Shenzhen Senior Technology Material Co. Ltd. is a corporation organized and existing under the laws of China, with its principal place of business in Shenzhen, Guangdong, China.

19. Shenzhen Senior Technology Material Co. Ltd. (US) Research Institute is registered to do business in the State of California and has an office and research and development facility in the State of California, located at 44049 Fremont Blvd., Fremont, California, 94538.

20. Both Shenzhen Senior Technology Material Co. Ltd. and Shenzhen Senior Technology Material Co. Ltd. (US) Research Institute are engaged in the business of developing, making, using, importing, offering to sell, and selling products, including coated separators and uncoated separators, to companies and institutions throughout the United States, including the State of California. Senior competes with Celgard in the battery separator market.

JURISDICTION AND VENUE

21. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

22. This Court has subject matter jurisdiction of the action pursuant to the patent laws of the United States, 35 U.S.C. § 1 *et seq.* and pursuant to 28 U.S.C. § 1331 because Celgard's claims against Senior for violation of the Defend Trade Secrets Act, 18 U.S.C. § 1831 *et seq.*, raise a federal question. This Court also has supplemental jurisdiction over the other claims pursuant to 28 U.S.C. § 1367 because they are so related to the original claim that they form part of the same case or controversy.

23. This Court has personal jurisdiction over each of the named defendants. As alleged herein, each defendant has had continuous and systematic contacts with the State of California,

has purposely directed activities at the State of California, and this action arises out of and relates to those activities. As alleged herein, each defendant's conduct occurred in California.

24. Venue is proper in this judicial district pursuant to 28 U.S.C. § 1391(c) because Shenzhen Senior Technology Material Co. Ltd. is a Chinese (foreign) corporation and not a resident in the United States and may be sued in any judicial district under 28 U.S.C. § 1391(c)(3).

25. Venue is also proper in this judicial district pursuant to 28 U.S.C. § 1391(b) because a substantial part of the events giving rise to Celgard's claims occurred within the Northern District of California.

FACTUAL ALLEGATIONS

A. Celgard and its Technology

26. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

27. Celgard has a broad portfolio of highly engineered products and is one of the largest suppliers of separators to the lithium-ion battery industry. Celgard has invested hundreds of millions of dollars into research and development for new battery separator technologies and is an innovator in both coated and uncoated separators.

28. Celgard has long been recognized as a leading innovator in the battery separator market. Celgard's technology, its reputation, its market leadership, and its customer loyalty comprise a significant portion of Celgard's value.

29. Celgard's customers are predominantly companies that supply batteries (or cells) or battery packs (or modules) to manufacturers that produce CE devices, EVs, and energy storage systems. EVs include both hybrid-EVs, like the Toyota Prius, and full-EVs, like Teslas.

30. In the past 20 years, rechargeable lithium-ion batteries became very popular for use in varying applications. Lithium-ion batteries provide a power source with a higher energy density, longer cycle life, and higher operational voltages with a relatively small size and light weight, as compared to other rechargeable batteries.

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31. Lithium batteries are typically constructed with a thin porous insulating film (the separator) that allows the battery to operate but prevents the electrodes (cathode and anode) from contacting each other. Liquid electrolyte fills the pores in the separator and voids in the electrodes. When the battery is discharged, positively charged lithium ions flow in the electrolyte from the anode, through the separator pores, to the cathode. This process leaves a negative charge of electrons on the anode. When charging, the flow is reversed. In a rechargeable (secondary) lithium battery, the charge and discharge states are repeated during use. The process of charging and discharging the battery is referred to as one cycle.

32. A typical lithium-ion battery cell includes a positive electrode and a negative electrode that is divided by a separator or film, with the electrodes typically being made of compatible metal materials. The electrodes and film are often soaked in (and reside in) a liquid or liquid-like electrolyte. Lithium ions move through the electrolyte between the two electrodes when the battery is discharging its energy (e.g., when the battery is plugged into a device and energizing the device) and also when the battery is charging (e.g., when the battery is plugged into a charging station). The separator prevents direct contact between the electrodes. This is critical because the touching of the two electrodes typically results in a “short” of the cell and possibly in catastrophic failure such as fire or explosion. Therefore, by providing a physical barrier between the electrodes, the separator facilitates safety and continued operation of the battery.

33. Separators made of various materials have been used over the years. As batteries have become more sophisticated, separator function has also become more demanding and complex.

34. Lithium batteries present certain unique safety challenges due to their chemical design and composition. One such challenge is lithium dendrite growth—the irregular growth of a metal on an electrode during charging or discharging. Over repetitive charge-discharge cycles, dendrites may grow out from the electrode’s surface in a needle-like structure. As the battery is cycled further, the dendrites may continue to grow, penetrating the separator and making direct, physical and electrical contact with the opposite electrode. When such contact is made, an

electrical short circuit of the battery may occur. This may cause the battery to malfunction. In certain scenarios, it may cause the battery's internal temperature to rise quickly and uncontrollably, leading to thermal runaway and catastrophic failure.

35. The battery industry has long identified dendrite growth (and associated electronic shorting) as a significant safety issue. Prior to the invention disclosed in the '520 patent, however, solutions to the problem were varied and achieved mixed results.

36. Celgard invented the separator technology described and claimed in the '520 patent to address safety and durability problems in lithium batteries. The separator claimed in the '520 patent, for example, in claim 12 of that patent includes, among other things, (1) a ceramic composite layer (or coating) including a mixture of inorganic particles and a matrix material, and (2) a polyolefinic microporous layer. The claimed separator's ceramic composite layer combines inorganic particles within a matrix material to create a composite layer adapted to at least block dendrite growth, which prevents electrical shorts, improving the safety and commercialization of high-energy lithium batteries. The claimed separator's polyolefinic microporous layer is adapted to block ionic flow between the anode and cathode at an elevated temperature such as during thermal runaway. This shutdown functionality further improves battery safety.

37. The '520 patent is based on a reissue application that was filed in 2015, issued in 2019, and will expire on April 10, 2020. The '520 patent is a Reissue of the 6,432,586 patent that was filed in 2000 and issued in 2002. Celgard is the owner by assignment of all right, title, and interest in and to the '520 patent, including the right to sue for past damages and injunctive relief.

38. The Patent Office has confirmed the validity of claim 12 of the '520 patent after three *inter partes* review challenges. A true and correct copy of U.S. Patent No. 6,432,586 ("the '586 patent"), the predecessor patent to the '520 patent, complete with *Inter Partes* Review Certificate is attached hereto as **Exhibit C**. On June 3, 2019, the validity of claim 12 was yet again confirmed in the Notice of Allowance in the reissue application that matured into the '520 patent.

39. Another of Celgard's inventions is an innovative way to remove a pin from a battery assembly. In the manufacture of high energy, lightweight batteries, for example,

secondary lithium batteries, the battery assembly, i.e., an anode tape and a cathode tape sandwiching a separator tape, is wound about one or more pins (or cores or mandrels). To begin winding of the assembly, the separator tape is taken up on the pin, and then the anode and cathode tapes are fed to the pin. Upon completion of the winding, the battery assembly is removed (or withdrawn) from the pin. If the assembly (i.e., the separator tape) sticks on the pin during withdrawal, the assembly "telescopes" and must be rejected. Such rejects increase the cost of the battery manufacturing process. In response to this problem, Celgard invented a separator having improved pin removal properties, i.e., separators that will not cause telescoping when the battery assembly is removed from the pin. This inventive separator is claimed in the '867 patent.

40. Celgard is the owner by assignment of all right, title, and interest in and to the '867 patent, including the right to sue for past damages and injunctive relief. The '867 patent was duly and legally issued by the United States Patent and Trademark Office on February 17, 2004, with all claims valid.

41. Celgard has invested in significant intellectual property protection and vigorously enforces its patents. Celgard's enforcement of the '520 patent (or its predecessor, the '586 patent) against infringing parties is well known within the battery and battery materials industry.

42. For example, In 2013, Celgard filed suit against Sumitomo Chemical Co., Ltd., in the United States District Court for the Western District of North Carolina for infringement of the '520 patent (or its predecessor, the '586 patent). The suit was resolved pursuant to agreement of the parties. The suit and its resolution were subject to at least national, industry-focused media coverage as shown in **Exhibit D** attached hereto.

43. In 2014, Celgard filed a patent infringement suit against LG Chem Ltd. and LG Chem America, Inc. (collectively, "LG Chem") in the United States District Court for the Western District of North Carolina for infringement of the '520 patent (or its predecessor, the '586 patent). The suit was resolved pursuant to agreement of the parties after significant district court litigation and patent office proceedings. The suit and its resolution were subject to at least national, industry-focused media coverage as shown in **Exhibit E** attached hereto.

44. In 2014, Celgard filed suit against SK Innovation Co., Ltd. ("SK Innovation") in the United States District Court for the Western District of North Carolina for infringement of the '520 patent (or its predecessor, the '586 patent). The suit was resolved pursuant to agreement of the parties after significant district court litigation and patent office proceedings. The suit and its resolution were subject to at least national, industry-focused media coverage as shown in **Exhibit F** attached hereto.

45. In December 2018, Celgard filed a patent infringement suit against MTI Corporation in the United States District Court for the Northern District of California for infringement of the '520 patent (or its predecessor, the '586 patent). *Celgard, LLC v. MTI Corporation*, No. 5:18-cv-07441-VKD (N.D. Cal. filed Dec. 11, 2018). The suit against MTI has settled and has been the subject of national and industry-focused media coverage. *See, e.g.*, **Exhibit G**.

46. In May 2019, Celgard filed a patent infringement suit against Targray Technology International Inc. ("Targray") in the United States District Court for the Northern District of California for infringement of the '520 patent (or its predecessor, the '586 patent). *Celgard, LLC v. Targray Technology International Inc.*, No. 5:19-cv-02401-VKD (N.D. Cal. filed May 2, 2019). The suit against Targray has settled and has been the subject of national and industry-focused media coverage. *See, e.g.*, **Exhibit H.**

47. At least as of February 25, 2019, Celgard provided notice to Shenzhen Senior Technology Material Co., Ltd. about its misappropriation of Celgard's trade secrets, as well as infringement of the '520 patent (or its predecessor, the '586 patent).

B. Market for Separators

48. When customers select a separator for use in a battery, they often face competing issues. For example, a battery design that has a high energy density might have a poor cycle life. One of the most important competing issues is between energy density and safety. Particularly for batteries with high capacity (e.g., those used in EVs), a defect in a separator can lead to an unsafe event—such as a battery fire or explosion. Accordingly, while a battery designer might want to

use a particularly thin separator to maximize energy density, a thin separator might be more susceptible to an unsafe condition than a thicker or coated separator.

49. Today, ceramic coated separators are increasingly common in the rechargeable (often large format) lithium batteries used in EVs and for other high-power applications. Much of the plug-in EV market in the U.S. has adopted ceramic coated separator technology. As the EV market continues to grow, an increasing percentage of manufacturers have turned to ceramic coated separators as a means to improve battery safety, battery cycle life, and vehicle driving range.

50. The market for plug-in EVs that use lithium-ion batteries, specifically, is rapidly expanding with an increasing number of makes and models available for sale. Vehicle manufacturers are rapidly increasing the number of available plug-in EVs as demand grows.

51. In the midst of this growth, vehicle manufacturers continue to explore options for increasing the per-charge EV driving range, often using, or making plans to use, a ceramic coated separator to achieve this objective. The success behind the growth of EVs is significantly correlated with longer per-charge driving range—a critical consumer criterion. The longer per-charge driving ranges now available in today's EVs are supported by very high energy density lithium-ion battery cells. The characteristics of these types of lithium-ion battery cells typically lead cell design engineers to specify ceramic coated separators to help address a balance between performance (i.e., longer per-charge driving range) and safety.

C. Battery Separator Supply Chain and Competition

52. Tiered supply chains are the rule in the EV and CE industries, where the final product consists of many complex components and sub-assemblies that must comply with stringent quality, manufacturing, and business standards. Celgard is an important member of the EV or CE tiered supply chain. As such, it typically supplies components to a battery supplier, who in turn supplies components directly to an original equipment manufacturer (OEM) that produces CE devices, EVs, or energy storage systems.

53. Competition for battery sales does not occur on a unit-by-unit basis. Rather, battery manufacturers compete to have EV or CE manufacturers use their batteries for an entire

product line. Supplying batteries and battery parts for EVs and CEs requires extensive testing and validation among the separator supplier, the battery manufacturer, and the EV or CE manufacturer. Once selected, the battery manufacturers "design in" a particular separator for that "generation"—i.e., that model's production life cycle—which, for EVs, lasts from two to five years, or more. Because many batteries are designed to last for years, and because the ramifications of a battery fire or explosion are so dire, manufacturers tend to stick with a battery design, and a particular separator, for a long time. The successful battery manufacturer (and separator manufacturer) thereby procures a blocking position that immunizes it from competition for several years.

54. Celgard's experience in the EV market provides a good illustration. Celgard often collaborates with its customers and potential customers to provide highly-engineered and specifically-designed separators for each customer or potential customer's requirements. Typically, the selling process for a separator requires a series of meetings between the separator supplier, the battery producer, and sometimes the OEM, where requirements are discussed, and sample separators are provided and evaluated. These sample separators may be tested as isolated units, or they may be built into working batteries. Following testing, the separator manufacturer may modify the separator, and the new separator and batteries built with it are retested. This iterative process can continue for months or even years, and it can continue through the approval process, and even can be used to make continuous improvements to the product after it is launched.

55. Over time, relationships are developed among the supplier, the tiered customer and the OEM at many levels during this process. Supplying components for an EV creates a familiarity and confidence that yields an "incumbency effect" that can carry over from one design cycle to the next. "Incumbency effect" increases the likelihood that the tiered suppliers and OEM will continue to harvest their initial investment through future contracts. Furthermore, through its experience in the EV industry, Celgard has learned that OEMs are more likely to look to their current suppliers for future designs, rather than to suppliers to which the OEMs have not already

awarded business, and other OEMs are more likely to select suppliers they know. All of this results in a strong competitive advantage for existing suppliers.

D. The Emerging Market in China for Separators

56. The Chinese government is seeking to have China become the global leader in lithium-ion battery technology, as well as the leader in EV technology. To facilitate these goals, the Chinese government provides subsidies for EVs, which in turn has caused demand for lithium-ion batteries to grow. According to market research, there are over 75 competing Chinese companies that are positioned to provide lithium-ion batteries with ceramic coated separators with many more attempting to enter the market, including international manufacturers that must either meet strict standards or partner with a Chinese company. To accommodate the increased demand for battery cells (and separators), Chinese manufacturers are adding large numbers of production lines for separators, raising the total manufacturing capability to over 1 billion square meter (m^2) per year of separators.

57. Receipt of subsidies from the Chinese government is conditioned on meeting certain requirements, including a minimum energy density for the batteries installed in the EV. Thus, as with other EV manufacturers, Chinese EV manufacturers have continued to explore options for increasing the per-charge driving range of EVs.

58. With large production capabilities and government subsidies, Chinese battery manufacturers and Chinese separator manufacturers can significantly discount the prices of their products, including separators.

59. One such company that manufactures coated and uncoated separators, including separators in China and significantly discounts prices for its separators is Senior.

E. Celgard's Trade Secrets and Confidential Information

60. In addition to its patent rights, Celgard has expended significant time, effort, and expertise to develop a variety of valuable trade secrets and confidential information related to its separator technology.

61. Celgard's trade secrets and confidential information apply to the designing, developing, manufacturing, finishing, distributing, and selling of its separators. Celgard's trade

secrets and confidential information relate to, for example, its resin technology, its dry process technology and include manufacturing methods, techniques, standard operating conditions (“SOC”), standard operating procedures (“SOP”), and processes, materials, performance issues (such as safety, temperature, battery life), suppliers, preferred resins, inspection and testing, resin properties, precursor properties, internal specifications, technical service, custom equipment, operating procedures, optimization of parameters, design, selling and marketing its products, and obtaining contracts and business with its customers.

62. Celgard’s trade secrets and confidential information further include know-how relating to raw materials, development and production, as well as know-how used to obtain supply and reduce costs throughout the supply chain.

63. Based on its extensive research and development, product testing, trials, and other investments and experience, Celgard has acquired trade secrets and confidential information regarding how to effectively manufacture separators to improve the safety of batteries, efficiently meet customer demand, and perform quality testing to ensure its products meet customer specifications and industry standards. Celgard also has acquired know-how on its combination of materials and optimization of properties.

64. Celgard takes reasonable steps to keep its trade secrets and confidential information confidential and to prevent their public disclosure. These steps include, but are not limited to: (1) requiring employees to sign non-disclosure agreements and adhere to a code of conduct; (2) making non-disclosure of trade secrets and confidential information and applicable security measures explicit in its employee hiring, training, and/or handbook; (3) restricting employee’s physical and electronic access to trade secrets and confidential information and to reports containing such information; (4) requiring a valid user login to access electronic information; (5) requiring employee badges to access Celgard offices and plants; and (6) extensive training.

65. As a result of its considerable investment in the development, manufacture, marketing, and sale of its products and its efforts made to protect its trade secrets and confidential information from public disclosure or use, Celgard has gained a distinct, commercial and

economic advantage in the separator market that has resulted in substantial sales and market share for its products.

F. Dr. Steven Zhang/Senior's Misappropriation of Celgard's Trade Secrets

66. Former Celgard employee, Dr. Steven Zhang, was employed by Celgard from 2005 until 2016. During that time, he held a number of positions, was part of the R&D department and function, and was an expert at Celgard in at least resins, polymers, membranes, base films, and process and production technology.

67. Dr. Zhang had climbed the ranks at Celgard, including being a Polypore Fellow, which is the highest technical rank in Polypore, as well as being a Celgard Technical Associate, which is the highest technical rank in Celgard.

68. During his time at Celgard, Dr. Zhang was an inventor or co-inventor on a number of Celgard patents, and was extensively and intimately involved with Celgard's separators' design, development, and production. As a result, Dr. Steven Zhang has unique, detailed, and extensive knowledge not only of Celgard's patented technology, but also of Celgard's trade secrets and confidential information relating to the design and manufacture of Celgard's separators, including, but not limited to, information relating to the materials, methods, production capacities, costs, and processes employed by Celgard in connection with the development, manufacture, and assembly of its products (trade secrets and confidential information that are kept strictly confidential and not reflected, for example, in its '520 or '867 patents or Celgard's other patents related to separators).

69. As a result of Dr. Zhang's access to Celgard's trade secrets and confidential information, Celgard prohibited him by contract and company policy from disclosing or using such information outside of his employment with Celgard.

70. As an example, Dr. Zhang signed a valid and binding written non-disclosure and non-solicitation agreement with Celgard (the "Non-Disclosure Agreement") which provides in relevant part:

> **Nondisclosure of Proprietary Information.** Employee recognizes that all Proprietary Information is the sole property of the Company. At all times, both during the employment by Employer and after the termination of such employment,

> Employee agrees to keep in the strictest confidence and trust all Proprietary Information. Employee will not disclose, transmit or use in any way any Proprietary Information (except as may be necessary to perform employee's duties and obligations as an Employee of the Employer) without the prior express written consent of the management of Employer.

The Non-Disclosure Agreement also provides:

> **Nonsolicitation of Supplies.** During the term of Employee's employment with Employer and for thirty-six (36) months after the date Employee ceases to be employed by Employer (the "Restricted Period"), Employee shall not, directly or indirectly request, induce or attempt to influence any supplier of goods or services to the Company to curtail or cancel any business it transacts with the Company.

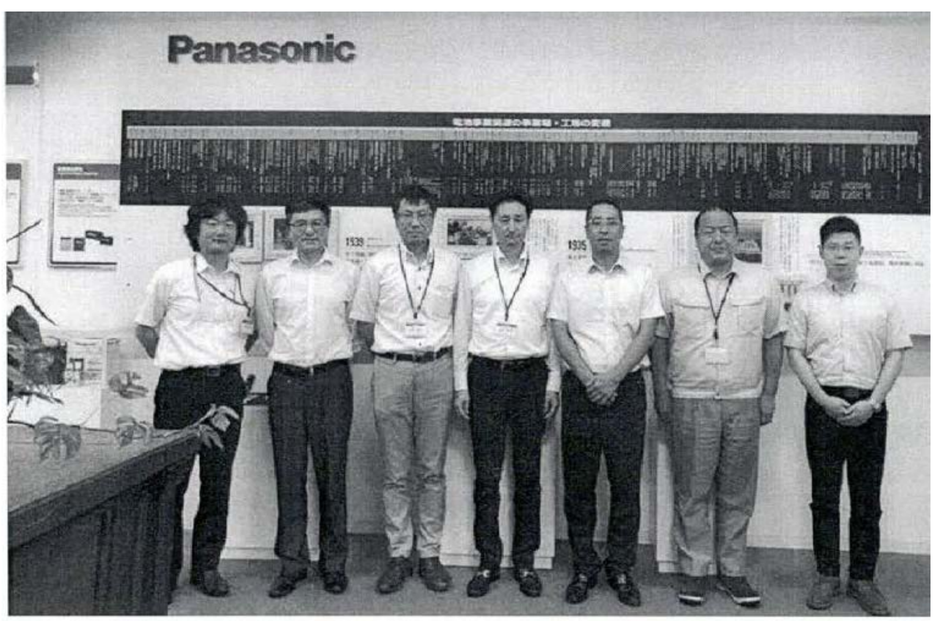
71. Dr. Zhang resigned from Celgard in October, 2016.

72. Dr. Zhang left Celgard for Senior. Upon information and belief, Dr. Zhang provided consulting services to Senior and/or was hired by Senior at least upon his departure from Celgard.

73. Dr. Steven Zhang (a/k/a Bin Wang) is the Chief Technology Officer (CTO) of Shenzhen Senior Technology Material Co. Ltd. in China and has a California address adjacent or part of the Shenzhen Senior Technology Material Co. Ltd. (US) Research Institute.

74. When Dr. Zhang left Celgard, he changed his name at least in China to Dr. Bin Wang, to avoid being identified by Celgard.

75. Celgard was able to locate him when it obtained a photograph of him at Panasonic on behalf of Senior (second on the left):



76. On February 25, 2019, after Celgard learned that Dr. Zhang was working at Senior, Celgard sent a letter to Shenzhen Senior Technology Material Co. Ltd. explaining that Dr. Zhang has received Celgard's trade secrets and confidential information while at Celgard and that it would be impossible for him to serve his role at Senior and not use "Polypore's or Celgard's confidential information, inventions, and trade secrets."

77. Thus, Senior was warned and had full knowledge of at least the '520 patent (or its predecessor, the '586 patent), and that Dr. Zhang possessed Celgard's trade secrets and confidential information from his time working at Celgard and that Senior was not permitted to use or benefit from such information.

78. Senior hired Dr. Zhang for the specific purpose of using his knowledge of Celgard's patented technology and trade secrets and confidential information to help Senior develop its infringing separators and to capitalize on his prior relationship and confidential knowledge about Celgard's customers.

79. By stealing Celgard's trade secrets and confidential information through Dr. Zhang, Senior was intentionally attempting to drive Celgard out of the market.

80. After stealing Celgard's trade secrets and confidential information, Senior's global market share increased. In 2017, Senior's global market share was 7% which was comparable to Celgard.

81. On information and belief, Dr. Zhang was directly involved in helping Senior design, develop, and devise a manufacturing process for the infringing separators, using Celgard's misappropriated trade secrets and confidential information. At least certain of Senior's infringing separators are detailed below.

82. Senior's separators greatly improved in quality after hiring Dr. Zhang. As an example, at least one particular property of Senior's separators was optimized after hiring Dr. Zhang. On information and belief, this property was optimized using Celgard's trade secrets and confidential information used and disclosed by Dr. Zhang.

83. Senior knew, or should have known, that Dr. Zhang had acquired Celgard's trade secrets and confidential information through his breach of his duty to Celgard to safeguard

Celgard's trade secrets and confidential information. Senior, on information and belief, has used this information taken from Celgard to develop and manufacture the infringing separators and has used and intends to continue to use this information to market and sell competing or infringing products.

84. Senior's infringement of the Asserted Patents and its misappropriation of Celgard's trade secrets, improper acquisition and use of Celgard's trade secrets and confidential information, and other wrongdoing has caused and will continue to cause Celgard to lose sales, customers, reputation, and market share for its products and thereby has caused and will continue to cause Celgard significant pecuniary harm for which it seeks injunctive relief and monetary damages and relief in an amount to be determined at trial.

85. Celgard has been and will continue to be irreparably harmed by Senior's infringing and unlawful activities.

G. Senior's Products

86. Senior is aware of Celgard and its products, including Celgard's separator products.

87. Senior offers for sale ceramic coated lithium-ion battery separators, including, but not limited to, those sold under at least the series designations SH, MCS, and MFS, those sold under at least the grades SH216, SH416, SH220, SH225, and SH230, and those sold under at least the model numbers SH420D14, SH420D22, SH416W14, SH416W22, SH216D14, SH216D22, SW312F (SH716W14, SH716W22), SW316E (SH220W14, SH220W22), SW320H (SH624W14, SH624W22), SH816D14, SH816D22, SH216Z14, SH216Z22, SH220D14, SH220D22, SH620D14, SH620D22, SH620T14, SH320Z14, SH224D14, SH224D22, SH624D14, SH624Z14, SH229D14, SH229D22, YV218D51A, YV718W51A, YT623D44A, and YT413W22.

88. Senior offers for sale uncoated polypropylene lithium-ion battery separators, including, but not limited to, those sold under at least the series designations SD, SQ, ST, and SZ, those sold at various thicknesses and porosity values, and those sold under at least the model numbers SD216C, SD216101, SD216001, SD216201, SD216E, SD216301, SD220C, SD220001,

SD220101, SD422201, SD220201, SD425201, SD425301, SD425401, SD432101, SD432201, SD432301, SD440201, SD440301, SQ212D, SD212202, SQ212F, SD214202, SQ214E, SD216102, SQ216C, SD216202, SD220102, SD220202, SD220202 (double layers), SD425202, SD460201, ST212D, ST212F, ST214C, ST216D, ST216E, ST218D, ST218F, ST420C, ST420E, and SZ212202.

89. These products are sold directly by Senior and/or through its distributors.

90. One such distributor for Senior's products is Targray.

91. Senior directly ships or drop ships separator products to customers even when customers purchase Senior separator products through a distributor, such as Targray.

92. Targray, for example, states of Senior's products that "[t]he latest addition to Targray's line of battery separators, our ceramic separators delivers an exceptional combination of safety, temperature performance and life cycle for lithium-ion battery manufacturers and R&D facilities. Given their rigorous safety and performance features, our ceramic separators are ideally suited for advanced li-ion battery applications, namely electric vehicles and energy storage systems."[1]

93. Senior's SH416W14 and SH416W22 separators are ceramic-coated wet process polyethylene separators, which "are also available with aluminum oxide ceramic coating to further enhance safety characteristics."[2]

94. Senior's SH216D14 and SH216D22 separators are "ceramic-coated dry process ceramic separators," which "are also available with aluminum oxide ceramic coating to further enhance safety characteristics."[3]

95. Senior's SH416W22 and SH216D22 are the double-side coated versions of SH416W14 and SH216D14, respectively.

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[1] https://www.targray.com/li-ion-battery/separators/ceramic-separators (last accessed April 5, 2019), attached as **Exhibit I**.
[2] "High-performance Separators," Targray—Battery Division, attached as **Exhibit J**, at 6.
[3] *Id.*

96. At least Senior's SH416W14, SH416W22, SH216D14, and SH216D22 separators[4] infringe at least Claim 12 of the '520 patent. Claim 12 of the '520 patent recites:

> A separator for an energy storage system comprises:
>
> at least one ceramic composite layer or coating, said layer including a mixture of 20-95% by weight of inorganic particles selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, TiO_2, SiS_2, $SiPO_4$, and mixtures thereof, and 5-80% by weight of a matrix material selected from the group consisting of polyethylene oxide, polyvinylidene fluoride, polytetrafluoroethylene, copolymers of the foregoing, and mixtures thereof, said layer being adapted to at least block dendrite growth and to prevent electronic shorting; and
>
> at least one polyolefinic microporous layer having a porosity in the range of 20-80%, an average pore size in the range of 0.02 to 2 microns, and a Gurley Number in the range of 15 to 150 sec, said layer being adapted to block ionic flow between an anode and a cathode.

97. The above-identified Senior ceramic coated separators comprise a ceramic composite layer or coating composed of inorganic particles of the nature and weight percentage (or the equivalent thereto) set forth in Claim 12 of the '520 patent. These Senior ceramic coated separator products have an "aluminum oxide ceramic coating to further enhance safety characteristics."[5]

98. The above-identified Senior ceramic coated separators comprise a ceramic composite layer or coating composed of a matrix material of the nature and weight percentage (or the equivalent thereto) set forth in Claim 12 of the '520 patent.

99. The above-identified Senior ceramic coated separators comprise a ceramic composite layer that is "adapted to at least block dendrite growth and to prevent electronic shorting," as set forth in Claim 12 of the '520 patent. On its website, Targray (Senior's distributor) acknowledged that these Senior "battery separators must be able to withstand penetration and branching moss-like crystalline minerals in order to prevent the contamination of electrodes. If the separator material is compromised, the performance of the high-power cell declines."[6]

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[4] Further investigation may reveal that other Senior ceramic coated separators also directly or indirectly infringe Claim 12 (or other claims) of the '520 patent.

[5] *Id.*

[6] https://www.targray.com/li-ion-battery/separators (last accessed Apr. 9, 2019), attached hereto as **Exhibit K**.

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100. The above-identified Senior ceramic coated separators comprise a polyolefinic microporous layer having porosity, average pore size, and Gurley Number measurements within the ranges (or the equivalents thereto) set forth in Claim 12 of the ’520 patent.

101. The above-identified Senior ceramic coated separators comprise a polyolefinic microporous layer that is “adapted to block ionic flow between an anode and a cathode,” as set forth in Claim 12 of the ’520 patent.

102. Further, at least Senior’s SD216C, SH420D14, SH420D22, SH320D14, SD216101, SD216001, SD216201, SH216D14, and SH216D22 separators[7] infringe at least Claim 17 of the ’867 patent. Claim 17 of the ’867 patent, for example, recites:

> A battery separator with improved pin removal properties comprising:
>
> a microporous membrane having a polypropylene surface portion including at least 50 ppm of a metallic stearate.

103. The above-identified Senior separators comprise a microporous membrane having a polypropylene surface portion including at least 50 ppm of a metallic stearate.

FIRST CLAIM FOR RELIEF

Infringement of the ’520 patent

104. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

105. Celgard is the owner by assignment of all rights, title, and interest in and to the ’520 patent.

106. The ’520 patent is valid and enforceable.

107. Upon information and belief, and in violation of 35 U.S.C. § 271(a), Senior has infringed and continues to infringe at least Claim 12 of the ’520 patent by making, using, offering for sale, selling, and/or importing in or into the United States ceramic coated separators covered by at least Claim 12 of the ’520 patent, including but not limited to at least Senior’s ceramic coated separators identified above by model number.

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[7] Further investigation may reveal that other Senior coated or uncoated separators also directly or indirectly infringe at least Claim 17, or even other claims, of the ’867 patent.

108. As a direct and proximate result of Senior's infringement of the '520 Patent, Celgard has been injured and has been caused significant harm and financial damages.

109. Upon information and belief, Senior has also induced and continues to induce infringement of at least Claim 12 of the '520 patent in violation of 35 U.S.C. § 271(b).

110. Senior induces its customers, purchasers, users, and/or developers of its separators to infringe at least Claim 12 of the '520 patent (or its predecessor, the '586 patent), and does so with specific intent, by providing instructions, directions, information, and/or knowledge on how to use its separators, and/or incorporate its separators into other products.

111. Senior has had knowledge of the '520 patent (or its predecessor, the '586 patent) at least as early as February 25, 2019. Nevertheless, Senior has continued to induce its customers, purchasers, users, and/or developers to infringe. It does so through documentation accompanying its separators, its technical support, advertisements, datasheets, demonstrations, and/or tutorials.

112. As a direct and proximate result of Senior's induced infringement of the '520 Patent, Celgard has been injured and has been caused significant harm and financial damages.

113. Upon information and belief, Senior, without Celgard's permission, has been and is presently infringing at least Claim 12 of the '520 patent in violation of 35 U.S.C. § 271(c), by selling or offering to sell material or apparatuses for use in practicing the '520 patent (and its predecessor, the '586 patent) that is a material part of the invention to its customers, purchasers, users, and/or developers.

114. The components sold or offered for sale by Senior have no substantial non-infringing uses. Further, they are not staple articles of commerce and constitute a material part of the invention. Thus, Senior knew or should have known that the combination for which its components were made was protected by the '520 patent (and its predecessor, the '586 patent), and yet Senior infringed upon the '520 patent in spite of this knowledge.

115. As such, Senior has contributorily infringed and continues to infringe the '520 patent, as set forth herein, knowing that the materials or components would be made or adapted for use in an infringing manner.

116. Senior's infringing acts have been and are the actual and proximate cause of damage to Celgard, and Celgard has sustained damages and harm and will continue to sustain damages and harm as a result of Senior's infringement of the '520 patent (and its predecessor, the '586 patent).

117. Senior has had actual knowledge of the '520 patent at least as of February 25, 2019. Senior's continued infringement on or after this date is in spite of the objectively high likelihood that its activities constitute infringement of a valid patent, and this risk was either known or so obvious that it should have been known to Senior. Thus, Senior's continued infringement at least as of February 25, 2019 or as of the filing of this Complaint is willful and deliberate.

118. Celgard has suffered and continues to suffer damages and irreparable harm as a result of Senior's past and ongoing infringement. Unless and until Senior's infringement is enjoined, Celgard will continue to be damaged and irreparably harmed.

119. Celgard is entitled to all remedies at law and equity, including, but not limited to, an injunction against Senior's infringement of the '520 patent pursuant to 35 U.S.C. § 283.

120. Celgard is entitled to damages for Senior's infringement of the '520 patent, including, but not limited to, damages pursuant to 35 U.S.C. §§ 284, 285.

SECOND CLAIM FOR RELIEF

Infringement of the '867 patent

121. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

122. Celgard is the owner by assignment of all rights, title, and interest in and to the '867 patent.

123. The '867 patent is valid and enforceable.

124. Upon information and belief, and in violation of 35 U.S.C. § 271(a), Senior has infringed and continues to infringe at least Claim 17 of the '867 patent by making, using, offering for sale, selling, and/or importing in or into the United States separators covered by at least Claim

17 of the ’867 patent, including, but not limited to, at least Senior’s separators identified above by model number.

125. As a direct and proximate result of Senior’s infringement of the ’867 Patent, Celgard has been injured and has been caused significant harm and financial damages.

126. Upon information and belief, Senior has also induced and continues to induce infringement of at least Claim 17 of the ’867 patent in violation of 35 U.S.C. § 271(b).

127. Senior induces its customers, purchasers, users, and/or developers of its separators to infringe at least Claim 17 of the ’867 patent, and does so with specific intent, by providing instructions, directions, information, and/or knowledge on how to use its separators, and/or incorporate its separators into other products.

128. Senior has had knowledge of the ’867 patent at least as early as the filing of this Complaint. Nevertheless, Senior has continued to induce its customers, purchasers, users, and/or developers to infringe. It does so through documentation accompanying its separators, its technical support, advertisements, datasheets, demonstrations, and/or tutorials.

129. As a direct and proximate result of Senior’s induced infringement of the ’867 Patent, Celgard has been injured and has been caused significant harm and financial damages.

130. Upon information and belief, Senior, without Celgard’s permission, has been and is presently infringing at least Claim 17 of the ’867 patent in violation of 35 U.S.C. § 271(c), by selling or offering to sell material or apparatuses for use in practicing the ’867 patent that is a material part of the invention to its customers, purchasers, users, and/or developers.

131. The components sold or offered for sale by Senior have no substantial non-infringing uses. Further, they are not staple articles of commerce and constitute a material part of the invention. Thus, Senior knew or should have known that the combination for which its components were made was protected by the ’867 patent and yet Senior infringed upon the ’867 patent in spite of this knowledge.

132. As such, Senior has contributorily infringed and continues to infringe the ’867 patent, as set forth herein, knowing that the materials or components would be made or adapted for use in an infringing manner.

133. Senior has had actual knowledge of the ’867 patent at least as of the filing of this Complaint. Senior’s continued infringement on or after this date is in spite of the objectively high likelihood that its activities constitute infringement of a valid patent, and this risk was either known or so obvious that it should have been known to Senior. Thus, Senior’s continued infringement at least as of the filing of this Complaint is willful and deliberate.

134. Celgard has suffered and continues to suffer damages and irreparable harm as a result of Senior’s past and ongoing infringement. Unless and until Senior’s infringement is enjoined, Celgard will continue to be damaged and irreparably harmed.

135. Celgard is entitled to all remedies at law and equity, including, but not limited to, an injunction against Senior’s infringement of the ’867 patent pursuant to 35 U.S.C. § 283.

136. Celgard is entitled to damages for Senior’s infringement of the ’867 patent, including, but not limited to, damages pursuant to 35 U.S.C. §§ 284, 285.

THIRD CLAIM FOR RELIEF

Misappropriation of Trade Secrets in Violation of the Defend Trade Secrets Act

(18 U.S.C. § 1836, *et seq.*)

137. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

138. Celgard owns and possesses certain trade secrets and confidential information, as alleged above.

139. Celgard’s trade secrets and confidential information related to at least its technical, logistical, and operational plans, manuals, programs, procedures, and the like concerning its resin technology, its dry process technology, including manufacturing methods, techniques, SOCs, SOPs, and processes, materials, performance issues (such as safety, temperature, battery life), suppliers, preferred resins, inspection and testing, resin properties, precursor properties, internal specifications, technical service, custom equipment, operating procedures, optimization of parameters, design, selling and marketing its products, and obtaining contracts and business with its customers, and other “know-how” constitute trade secrets as defined by the Defend Trade Secrets Act.

140. Celgard maintains its trade secrets and confidential information as confidential and does not share them with competitors or the public.

141. Celgard keeps its trade secrets and confidential information alleged in this Complaint confidential and has undertaken strict efforts to maintain the secrecy of the trade secrets and confidential information at issue. These efforts include, but are not limited to, requiring its employees to sign confidentiality agreements as conditions of their employment, maintaining confidential information on a secure server, extensive training, adherence with its policies, implementing robust document control systems to protect its trade secrets and confidential information, and restricting access to and protecting its trade secrets and confidential information.

142. Celgard's trade secrets and confidential information described herein derive independent economic value from not being generally known to, and not being readily ascertainable through proper means by, others who could obtain economic value from the disclosure or use of the information.

143. Such trade secrets and confidential information constitute "trade secrets" within the meaning of the Defend Trade Secrets Act.

144. Celgard's trade secrets and confidential information were made available to Dr. Steven Zhang during his employment with Celgard under circumstances requiring him to maintain the trade secrets and confidential information in confidence.

145. Senior knew or should have known under the circumstances that the information misappropriated were trade secrets and confidential information.

146. Celgard is informed and believes, and on that basis alleges, that Senior has been and is now using Celgard's trade secrets and confidential information, without its consent, to produce many of its separators.

147. Celgard is informed and believes, and on that basis alleges, that if Senior is not enjoined, Senior will continue to misappropriate and use Celgard's trade secrets and confidential information for its own benefit and to Celgard's detriment.

148. As a direct and proximate result of Senior's conduct, Celgard has been damaged in an amount to be proven at trial. Celgard also has incurred, and will continue to incur, additional damages, costs, and expenses, including attorneys' fees and costs, as a result of Senior's misappropriation. As a further proximate result of the misappropriation and use of Celgard's trade secrets and confidential information, Senior was unjustly enriched.

149. If Senior's conduct is not stopped, Celgard will continue to suffer competitive harm and irreparable injury. Because Celgard's remedy at law is inadequate, Celgard seeks, in addition to damages, temporary, preliminary, and permanent injunctive relief to recover and protect its trade secrets and confidential information and other legitimate business interests.

150. In performing the conduct described herein, Senior acted willfully and maliciously, intending to injure Celgard and to wrongfully obtain an advantage at Celgard's expense and detriment. As a result of this conduct, Celgard is entitled to an award of exemplary damages against Senior as well as attorneys' fees and costs incurred in this action.

FOURTH CLAIM FOR RELIEF

Misappropriation of Trade Secrets in Violation of Cal. Civ. Code § 3426, *et seq.*

151. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

152. Celgard owns and possesses certain trade secrets and confidential information, as alleged above.

153. Celgard's trade secrets and confidential information related to at least its technical, logistical, and operational plans, manuals, programs, procedures and the like concerning its resin technology, its dry process technology, including manufacturing methods, techniques, SOCs, SOPs, and processes, materials, performance issues (such as safety, temperature, battery life), suppliers, preferred resins, inspection and testing, resin properties, precursor properties, internal specifications, technical service, custom equipment, operating procedures, optimization of parameters, design, selling and marketing its products, and obtaining contracts and business with its customers, and other "know how" constitute trade secrets as described above and defined by California's Uniform Trade Secrets Act.

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154. Celgard keeps the trade secret information alleged in this Complaint confidential and has undertaken strict efforts to maintain the secrecy of the trade secrets at issue, as discussed above. Celgard's trade secret information described herein derives independent economic value from not being generally known to the public or others who could obtain economic value from their disclosure or use (such as competitors).

155. Such confidential information constitutes trade secrets within the meaning of California Civil Code Section 3426.1.

156. Celgard's confidential, proprietary, and trade secret information was made available to Dr. Steven Zhang during his employment with Celgard under circumstances requiring him to maintain the information in confidence.

157. Senior misappropriated Celgard's trade secret information at least by acquiring such information improperly from and by hiring Dr. Steven Zhang.

158. Senior knew or should have known under the circumstances that the information misappropriated was trade secret information.

159. Celgard is informed and believes, and on that basis alleges, that Senior is now using Celgard's trade secrets, without its consent, to produce many of its separators.

160. Senior's misconduct detailed herein constitutes misappropriation of Celgard's trade secrets and violates Section 3426 *et seq.* of the California Civil Code. As a direct and proximate result of Senior's conduct, Celgard has been damaged in an amount to be proven at trial. Celgard also has incurred, and will continue to incur, additional damages, costs, and expenses, including attorneys' fees and costs, as a result of Senior's misappropriation. As a further proximate result of the misappropriation and use of Celgard's trade secrets, Senior was unjustly enriched.

161. Pursuant to Section 3426.2 of the California Civil Code, Celgard is entitled to an injunction to prohibit Senior from using, disclosing and/or otherwise benefiting from Celgard's trade secrets, to eliminate any commercial advantage that Senior may otherwise derive from their misappropriation, and to require Senior to immediately return to Celgard all trade secret, know-how, and confidential information, documents, and any other misappropriated materials.

162. Pursuant to Section 3426.3 of the California Civil Code, Celgard is entitled to recover its damages incurred by virtue of Senior's wrongful misappropriation of its trade secrets, in addition to disgorgement of all amounts by which Senior has been unjustly enriched, or the payment of a reasonable royalty, in an amount to be proven at trial.

163. In performing the conduct described herein, Senior acted willfully and maliciously, intending to injure Celgard and to wrongfully obtain an advantage at Celgard's expense. Under Section 3426.3 of the California Civil Code, Celgard is entitled to all remedies available under the law to compensate Celgard, including, but not limited to, an award of exemplary damages against Senior.

164. Pursuant to Section 3426.4 of the California Civil Code, Celgard also is entitled to an award of its attorneys' fees and costs incurred in this action.

165. Because Celgard's remedy at law is inadequate, Celgard further is entitled to preliminary and permanent injunctive relief to recover and protect its confidential, proprietary, and trade secret information and other legitimate business interests.

FIFTH CLAIM FOR RELIEF

Violation of Cal. Bus & Prof. Code § 17200, *et seq.*

166. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

167. California Business and Professions Code section 17200 prohibits unfair competition in the form of any unlawful, unfair, or fraudulent business practice.

168. Senior knowingly performed acts to pirate away the fruits of Celgard's customer base, including, but not limited to: interfering with the prospective economic advantage Celgard has with its customers, deceiving the customers, diverting and attempting to divert the customers through use of trade secrets and confidential information misappropriated from Celgard, and by engaging in other acts alleged herein. These acts constitute unlawful, unfair, and/or fraudulent business practices and unfair competition prohibited under California Business and Professions Code Sections 17200 *et seq*.

169. As alleged more fully above, Senior took Celgard's trade secrets and confidential information related to, but not limited to, its technical, logistical, and operational plans, manuals, programs, procedures and the like concerning its resin technology, its dry process technology, including manufacturing methods, techniques, SOCs, SOPs, and processes, materials, performance issues (such as safety, temperature, battery life), suppliers, preferred resins, inspection and testing, resin properties, precursor properties, internal specifications, technical service, custom equipment, operating procedures, optimization of parameters, design, selling and marketing its products, and obtaining contracts and business with its customers, and other "know-how."

170. Senior has benefited from these acts in the form of unfair advantages in developing, producing, and selling its separators.

171. As a result of such acts, Celgard has suffered damage in an amount as yet unknown, and if Senior's conduct is not stopped, Celgard will continue to suffer irreparable injury and significant damages, in an amount to be proven at trial.

172. Until relief is granted to Celgard, Celgard will be harmed and Senior will be unjustly enriched, which unjust enrichment should be disgorged pursuant to allowable remedies under California Business and Professions Code Sections 17200 *et seq*.

SIXTH CLAIM FOR RELIEF

Inducing Breach of Contract

173. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

174. As set forth above, Dr. Steven Zhang and Celgard entered into a Confidentiality and Non-solicitation Agreement, a valid contract, on or about July 18, 2005.

175. Senior knew, or should have known, of the existence of the Confidentiality and Non-solicitation Agreement described above, including at least because it engaged in consulting services with Dr. Zhang, and employed Dr. Zhang as Senior's CTO at least after he was employed at Celgard, which proximately caused Dr. Zhang's breach of his agreement.

176. Upon information and belief, Senior intended to cause Dr. Zhang to breach his agreement with Celgard.

177. As a result of Senior's actions, Dr. Zhang did in fact breach his agreement with Celgard at least during the time he was providing consulting services to Senior or serving as Senior's CTO, as Dr. Bin Wang.

178. Senior's intentional acts have damaged and continue to damage Celgard in an amount to be determined at trial, of at least a reasonable royalty and/or lost profits that Celgard would have made but for Senior's inducing Dr. Zhang's beach of his agreement with Celgard.

179. In addition, the aforementioned acts of Senior were done willfully and maliciously, and Celgard is entitled to punitive and exemplary damages in an amount to be shown according to proof at trial.

SEVENTH CLAIM FOR RELIEF

Intentional Interference with Prospective Economic Relations

180. Celgard repeats and incorporates by reference all prior allegations of this Complaint as if fully set forth herein.

181. Celgard had a long relationship with a former customer that was worth potentially millions of dollars, that, if it had continued, would have benefited Celgard.

182. Upon information and belief, Senior knew of Celgard's longstanding economic relationship with this former customer.

183. Senior used Celgard's misappropriated trade secrets and confidential information to unfairly compete against Celgard and impede Celgard's existing relationship with this customer.

184. On information and belief, Senior intended to disrupt Celgard's business and economic relationship with this former customer by and through using Celgard's trade secrets and confidential information and selling its knockoff separators at deeply discounted prices.

185. As a direct result of Senior's wrongful conduct, this customer terminated its contract with Celgard and awarded at least a portion of that business to Senior.

186. Senior's conduct was a substantial factor in causing Celgard's harm.

187. As a direct and proximate result of Senior's interference with Celgard's economic relationship with this former customer, Celgard has been and continues to be injured irreparably and otherwise, and has sustained significant damages, in an amount to be determined by the evidence at trial. Additionally, Senior has been and will continue to be unjustly enriched in an amount to be proven at trial. Senior's unjust enrichment includes, but is not limited to, its award of Celgard's lucrative account with this former customer and its receipt of business opportunities that rightly belong to Celgard.

188. Senior performed the foregoing acts, conduct, and omissions maliciously and oppressively, with the intent to damage Celgard. By reason of this conduct, Celgard has been damaged by Defendants' intentional interference with its contractual relations, and is entitled to damages in amount to be determined at trial, as well as an award of exemplary damages and attorneys' fees and costs.

JURY DEMAND

Pursuant to Civ. L.R. 3-6 and Fed. R. Civ. P. 38, Celgard hereby requests a trial by jury.

REQUEST FOR RELIEF

Celgard respectfully asks that the Court enter judgment in its favor as follows:

A. Judgment in favor of Celgard and against Senior on each cause of action alleged herein;

B. Finding that Senior has infringed and is infringing the Asserted Patents;

C. Finding that Senior's infringement of the Asserted Patents has been and continues to be willful;

D. Awarding Celgard damages adequate to compensate it for Senior's past and present infringement, but in no event less than a reasonable royalty;

E. Awarding an accounting and supplemental damages for those acts of infringement committed by Senior subsequent to the discovery cut-off date in this action through the date Final Judgment is entered;

F. Ordering that damages for infringement of the Asserted Patent(s) be trebled as provided for by 35 U.S.C. § 284 for Senior's willful infringement of the Asserted Patents;

G. That Celgard be awarded its full actual and consequential damages according to proof at trial;

H. That Celgard be awarded Senior's unjust enrichment and restitution to the fullest extent available under applicable law;

I. That Celgard be awarded punitive, enhanced, and/or exemplary damages, including but not limited to at least doubled damages and unjust enrichment under Cal. Civ. Code Section 3426, to the fullest extent available under applicable law;

J. Finding that this case is exceptional;

K. Awarding Celgard its attorneys' fees and costs, together with prejudgment and post-judgment interest;

L. Preliminary and permanent injunctive relief pursuant to which Defendants, and each of them, and their employees or representatives, and all persons acting in concert or participating with them are ordered, enjoined, or restrained, directly or indirectly, by any means whatsoever, as follows:

a. From disclosing or using Celgard's trade secrets and confidential information;

b. From making, testing, using, promoting, offering to sell, marketing, commercializing, or selling separators or products of any kind that utilize, embody, or were developed, in whole or in part, with the benefit or use of any of Celgard's trade secrets and/or confidential information;

c. From utilizing any processes or methods that are derived from, contain, or embody, in whole or in part, any of Celgard's trade secrets and/or confidential information;

d. From submitting to or filing with any regulatory body, including but not limited to, the United States Patent and Trademark Office, any documents or

other materials (in paper, electronic, or any other form) that are derived from, contain, embody, in whole or in part, any of Celgard's trade secrets and/or confidential information;

e. Immediately to preserve and return to Celgard (i) all copies of all Celgard documents and information, including without limitation any trade secrets and/or confidential information acquired from Celgard and documents and information containing Celgard trade secrets and/or confidential information; and (ii) all copies of all materials (in paper, electronic, or any other form) containing any, or derived from any, Celgard trade secrets and/or confidential information; and

f. To identify each individual and entity to whom or to which Defendants and any of their employees or representatives, and all persons acting in concert or participating with them, disclosed (i) any Celgard documents or other materials (in paper, electronic, or any other form) or (ii) any of Celgard's trade secrets and/or confidential information; and

g. To turn over to the Court any proceeds Defendants have received from the misappropriation of Celgard's trade secrets and/or confidential information, which proceeds would be held in constructive trust until the conclusion of this litigation;

M. An award of exemplary damages against Senior , as well as attorneys' fees and costs incurred in this action;

N. An award of punitive and exemplary damages against Senior;

O. A preliminary and permanent injunction against Senior's, and their employees or representatives, and all persons acting in concert or participating with them, continued direct and indirect infringements, misappropriations, and uses of Celgard's trade secrets and confidential information, or any products or marketing materials including or based upon Celgard's trade secrets and confidential information;

P. To the extent injunctive relief is not awarded, awarding Celgard damages adequate to compensate Celgard for Senior's future infringement, misappropriations, and any uses of Celgard's trade secrets and confidential information, but in no event less than a reasonable royalty; and

Q. Any further relief that this Court deems just and proper.

DATED: September 16, 2019

Respectfully submitted,

/s/ Li Zhu ________________________________

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EXHIBIT A

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Zhang

(10) Patent Number: US RE47,520 E
(45) Date of Reissued Patent: Jul. 16, 2019

(54) **SEPARATOR FOR A HIGH ENERGY RECHARGEABLE LITHIUM BATTERY**

(71) Applicant: **Zhengming Zhang**, Rock Hill, SC (US)

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(21) Appl. No.: **14/875,434**

(22) Filed: **Oct. 5, 2015**

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H01M 2/16 (2006.01)
H01M 10/052 (2010.01)

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CPC ***H01M 2/1686*** (2013.01); ***H01M 2/164*** (2013.01); ***H01M 2/166*** (2013.01); ***H01M 2/1653*** (2013.01); *H01M 10/052* (2013.01)

(58) **Field of Classification Search**
CPC .. H01M 2/1686; H01M 2/1653; H01M 2/164; H01M 2/166; H01M 10/052
See application file for complete search history.

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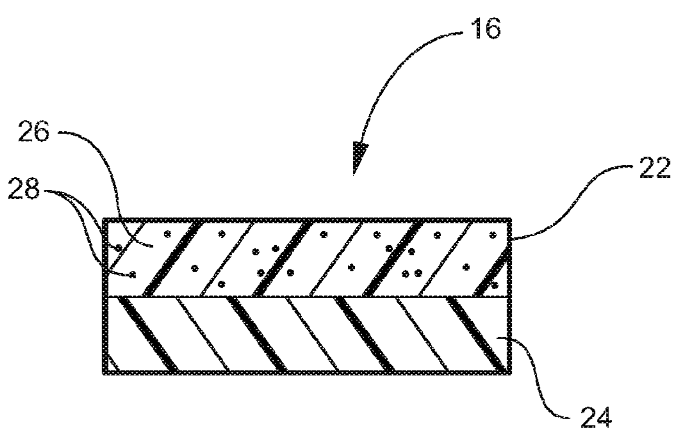
(57) **ABSTRACT**

The instant invention is directed to a separator for a high energy rechargeable lithium battery and the corresponding battery. The separator includes a ceramic composite layer and a polymeric microporous layer. The ceramic layers includes a mixture of inorganic particles and a matrix material. The ceramic layer is adapted, at least, to block dendrite growth and to prevent electronic shorting. The polymeric layer is adapted, at least, to block ionic flow between the anode and the cathode in the event of thermal runaway.

28 Claims, 1 Drawing Sheet



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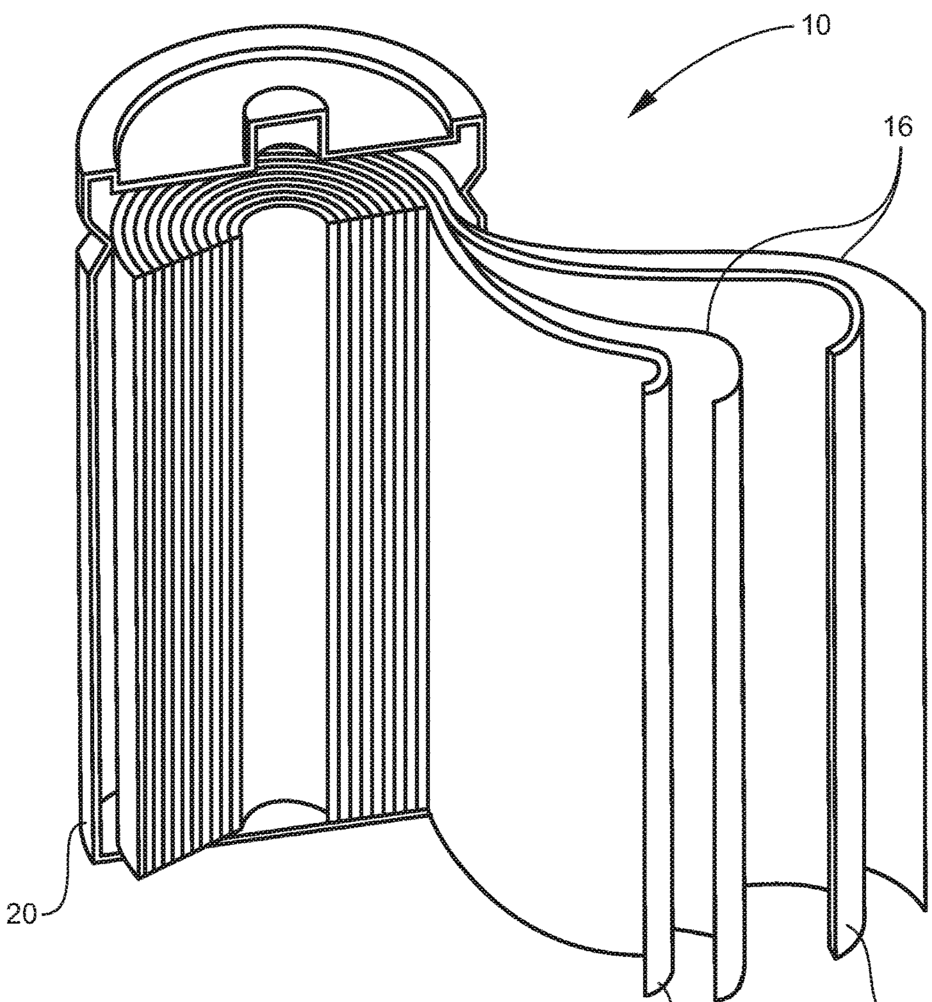

Fig. 1

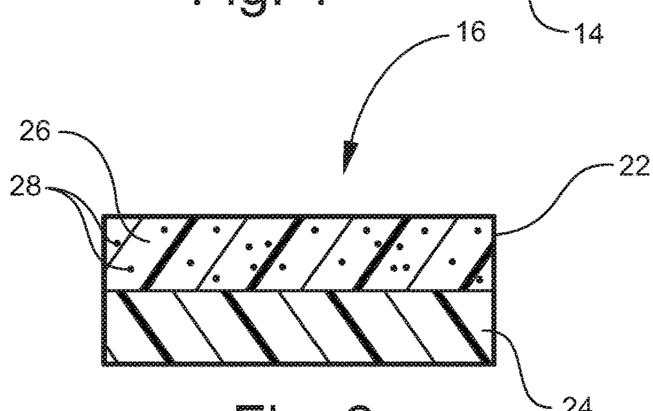

Fig. 2

Amended

SEPARATOR FOR A HIGH ENERGY RECHARGEABLE LITHIUM BATTERY

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

FIELD OF THE INVENTION

A separator for a high energy rechargeable lithium battery and a high energy rechargeable lithium battery are disclosed herein.

BACKGROUND OF THE INVENTION

A high energy rechargeable lithium battery has an anode with an energy capacity of at least 372 milliampere-hours/gram (mAh/g). Such anodes include, for example, lithium metal, lithium alloys (e.g. lithium aluminum), and mixtures of lithium metal or lithium alloys and materials such as carbon, nickel, and copper. Such anodes exclude anodes solely with lithium intercalation or lithium insertion compounds.

The commercial success of lithium metal or lithium alloy batteries has eluded all but primary cells due to persistent safety problems.

The difficulties associated with the use of the foregoing anodes stem mainly from lithium dendrite growth that occurs after repetitive charge-discharge cycling. (While dendrite growth is a potential problem with any lithium battery, the severity of the problem with the above-mentioned high energy anodes is much greater than with other lithium anodes (e.g. pure carbon intercalation anodes) as is well known in the art.) When lithium dendrites grow and penetrate the separator, an internal short circuit of the battery occurs (any direct contact between anode and cathode is referred to as "electronic" shorting, and contact made by dendrites is a type of electronic shorting). Some shorting (i.e., a soft short), caused by very small dendrites, may only reduce the cycling efficiency of the battery. Other shorting may result in thermal runaway of the lithium battery, a serious safety problem for lithium rechargeable battery.

The failure to control the dendrite growth from such anodes remains a problem, limiting the commercialization of cells with those anodes, particularly those cells with liquid organic electrolytes.

Accordingly, there is a need to improve high energy rechargeable lithium batteries.

SUMMARY OF THE INVENTION

The instant invention is directed to a separator for a high energy rechargeable lithium battery and the corresponding battery. The separator includes at least one ceramic composite layer and at least one polymeric microporous layer. The ceramic composite layer includes a mixture of inorganic particles and a matrix material. The ceramic composite layer is adapted, at least, to block dendrite growth and to prevent electronic shorting. The polymeric layer is adapted, at least, to block ionic flow between the anode and the cathode in the event of thermal runaway.

DETAILED DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred;

it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is a sectional view of a lithium metal battery.

FIG. **2** is a cross-sectional view of the separator.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the figures, wherein like numerals indicate like elements, there is shown in FIG. **1** a lithium metal battery (or cell) **10**. Lithium metal cell **10** comprises a lithium metal anode **12**, a cathode **14**, and a separator **16** disposed between anode **12** and cathode **14**, all of which is packaged within a can **20**. The illustrated cell **10** is a cylindrical cell or 'jelly roll' cell, but the invention is not so limited. Other configurations, for example, prismatic cells, button cells, or polymer cells are also included. Additionally, not shown is the electrolyte. The electrolyte may be a liquid (organic or inorganic), or a gel (or polymer). The invention will be, for convenience, described with regard to a c ylindrical cell with a liquid organic electrolyte, but it is not so limited and may find use in other cell types (e.g. energy storage system, combined cell and capacitor) and configurations.

The anode **12** should have an energy capacity greater than or equal to 372 mAh/g, preferably ≥700 mAh/g, and most preferably ≥1000 mAH/g. Anode **12** may be constructed from a lithium metal foil or a lithium alloy foil (e.g. lithium aluminum alloys), or a mixture of a lithium metal and/or lithium alloy and materials such as carbon (e.g. coke, graphite), nickel, copper. The anode **12** is not made solely from intercalation compounds containing lithium or insertion compounds containing lithium.

The cathode **14** may be any cathode compatible with the anode and may include an intercalation compound, an insertion compound, or an electrochemically active polymer. Suitable intercalation materials includes, for example, MoS_2, FeS_2, MnO_2, TiS_2, $NbSe_3$, $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$, V_6O_{13}, V_2O_5, and $CuCl_2$. Suitable polymers include, for example, polyacetylene, polypyrrole, polyaniline, and polythiopene.

The electrolyte may be liquid or gel (or polymer). Typically, the electrolyte primarily consists of a salt and a medium (e.g. in a liquid electrolyte, the medium may be referred to as a solvent; in a gel electrolyte, the medium may be a polymer matrix). The salt may be a lithium salt. The lithium salt may include, for example, $LiPF_6$, $LiAsF_6$, $LiCF_3SO_3$, $LiN(CF_3SO_3)_3$, $LiBF_6$, and $LiClO_4$, BETTE electrolyte (commercially available from 3M Corp. of Minneapolis, MN) and combinations thereof. Solvents may include, for example, ethylene carbonate (EC), propylene carbonate (PC), EC/PC, 2-MeTHF(2-methyltetrahydrofuran)/EC/PC, EC/DMC (dimethyl carbonate), EC/DME (dimethyl ethane), EC/DEC (diethyl carbonate), EC/EMC (ethylmethyl carbonate), EC/EMC/DMC/DEC, EC/EMC/DMC/DEC/PE, PC/DME, and DME/PC. Polymer matrices may include, for example, PVDF (polyvinylidene fluoride), PVDF:THF (PVDF:tetrahydrofuran), PVDF:CTFE (PVDF:chlorotrifluoro ethylene) PAN (polyacrylonitrile), and PEO (polyethylene oxide).

Referring to FIG. **2**, separator **16** is shown. Separator **16** comprises a ceramic composite layer **22** and a polymeric microporous layer **24**. The ceramic composite layer is, at least, adapted for preventing electronic shorting (e.g. direct or physical contact of the anode and the cathode) and blocking dendrite growth. The polymeric microporous layer

is, at least, adapted for blocking (or shutting down) ionic conductivity (or flow) between the anode and the cathode during the event of thermal runaway. The ceramic composite layer **22** of separator **16** must be sufficiently conductive to allow ionic flow between the anode and cathode, so that current, in desired quantities, may be generated by the cell. The layers **22** and **24** should adhere well to one another, i.e. separation should not occur. The layers **22** and **24** may be formed by lamination, coextrusion, or coating processes. Ceramic composite layer **22** may be a coating or a discrete layer, either having a thickness ranging from 0.001 micron to 50 microns, preferably in the range of 0.01 micron to 25 microns. Polymeric microporous layer **24** is preferably a discrete membrane having a thickness ranging from 5 microns to 50 microns, preferably in the range of 12 microns to 25 microns. The overall thickness of separator **16** is in the range of 5 microns to 100 microns, preferably in the range of 12 microns to 50 microns.

Ceramic composite layer **22** comprises a matrix material **26** having inorganic particles **28** dispersed therethrough. Ceramic composite layer **22** is nonporous (it being understood that some pores are likely to be formed once in contact with an electrolyte, but ion conductivity of layer **22** is primarily dependent upon choice of the matrix material **26** and particles **28**). The matrix material **26** of layer **22** differs from the foregoing polymer matrix (i.e., that discussed above in regard to the medium of the electrolyte) in, at least, function. Namely, matrix material **26** is that component of a separator which, in part, prevents electronic shorting by preventing dendrite growth; whereas, the polymer matrix is limited to the medium that carries the dissociated salt by which current is conducted within the cell. The matrix material **26** may, in addition, also perform the same function as the foregoing polymer matrix (e.g. carry the electrolyte salt). The matrix material **26** comprises about 5-80% by weight of the ceramic composite layer **22**, and the inorganic particles **28** form approximately 20-95% by weight of the layer **22**. Preferably, composite layer **22** contains inorganic particles 30%-75% by weight. Most preferably, composite layer **22** contains inorganic particles 40%-60% by weight.

The matrix material **26** may be ionically conductive or non-conductive, so any gel forming polymer suggested for use in lithium polymer batteries or in solid electrolyte batteries may be used. The matrix material **26** may be selected from, for example, polyethylene oxide (PEO), polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), polyurethane, polyacrylonitrile (PAN), polymethylmethacrylate (PMMA), polytetraethylene glycol diacrylate, copolymers thereof, and mixtures thereof. The preferred matrix material is PVDF and/or PEO and their copolymers. The PVDF copolymers include PVDF:HFP (polyvinylidene fluoride:hexafluoropropylene) and PVDF: CTFE (polyvinylidene fluoride:chlorotrifluoroethylene). Most preferred matrix materials include PVDF:CTFE with less than 23% by weight CTFE, PVDH:HFP with less than 28% by weight HFP, any type of PEO, and mixtures thereof.

The inorganic particles **28** are normally considered non-conductive, however, these particles, when in contact with the electrolyte, appear, the inventor, however, does not wish to be bound hereto, to develop a superconductive surface which improves the conductivity (reduces resistance) of the separator **16**. The inorganic particles **28** may be selected from, for example, silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), calcium carbonate ($CaCO_3$), titanium dioxide (TiO_2), SiS_2, $SiPO_4$ and the like, or mixtures thereof. The preferred inorganic particle is SiO_2, Al_2O_3, and $CaCO_3$. The particles may have an average particle size in the range of 0.001 micron to 25 microns, most preferably in the range of 0.01 micron to 2 microns.

The microporous polymeric layer **24** consists of any commercially available microporous membranes (e.g. single ply or multi-ply), for example, those products produced by Celgard Inc. of Charlotte, North Carolina, Asahi Chemical of Tokyo, Japan, and Tonen of Tokyo, Japan. The layer **24** has a porosity in the range of 20-80%, preferably in the range of 28-60%. The layer **24** has an average pore size in the range of 0.02 to 2 microns, preferably in the range of 0.08 to 0.5 micron. The layer **24** has a Gurley Number in the range of 15 to 150 sec, preferably 30 to 80 sec. (Gurley Number refers to the time it takes for 10 cc of air at 12.2 inches of water to pass through one square inch of membrane.) The layer **24** is preferably polyolefinic. Preferred polyolefins include polyethylene and polypropylene. Polyethylene is most preferred.

The foregoing separator, while primarily designed for use in high energy rechargeable lithium batteries, may be used in other battery systems in which dendrite growth may be a problem.

The foregoing shall be further illustrated with regard to the following non-limiting examples.

EXAMPLES

Sixty (60) parts of fine particle calcium carbonate, 40 parts of PVDF:HFP (Kynar 2801), are dissolved in 100 parts of acetone at 35° C. for 3 hours under high shear mixing. The solution is cast into a 15 micron film. After vaporization of the actone at room temperature, the composite film was thermally laminated with 2 layers (8 microns) of Celgard 2801 membrane. The resulting composite shutdown separator has a structure of PE/composite/PE and a thickness of 30 microns.

Thirty (30) parts of silicon dioxide, 30 parts of calcium carbonate, 40 parts of PVDF:HFP (Kynar 2801) are dissolved in 100 parts of acetone at 35° C. for 3 hours under high shear mixing. This solution was cast or coated onto a 23 micron layer of a polyethylene microporous layer made by Celgard Inc. After vaporization of the acetone at room temperature, the polyethylene/composite membrane had a thickness of 38 microns.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicating the scope of the invention.

What is claimed is:

[1. A separator for a high energy rechargeable lithium battery comprises:

at least one ceramic composite layer, said layer including a mixture of inorganic particles in a matrix material; said layer being adapted to at least block dendrite growth and to prevent electronic shorting; and

at least one polyolefinic microporous layer, said layer being adapted to block ionic flow between an anode and a cathode.**]**

[2. The separator according to claim **1** wherein said mixture comprises between 20% to 95% by weight of said inorganic particles and between 5% to 80% by weight of said matrix material.**]**

[3. The separator according to claim **1** wherein said inorganic particles are selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, TiO_2, SiS_2, $SiPO_4$, and mixtures thereof.**]**

[**4**. The separator according to claim **1** wherein said matrix material is selected from the group consisting of polyethylene oxide, polyvinylidene fluoride, polytetrafluoroethylene, polyurethane, polyacrylonitrile, polymethylmethacrulate, polytetraethylene glycol diacrylate, copolymers thereof, and mixtures thereof.]

[**5**. The separator according to claim **1** wherein said polyolefinic microporous layer is a polyolefinic membrane.]

[**6**. The separator according to claim **5** wherein said polyolefinic membrane is a polyethylene membrane.]

[**7**. A separator for a high energy rechargeable lithium battery comprises:

at least one ceramic composite layer or coating, said layer including a mixture of 20-95% by weight of inorganic particles selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, TiO_2, SiS_2, $SiPO_4$, and mixtures thereof, and 5-80% by weight of a matrix material selected from the group consisting of polyethylene oxide, polyvinylidene fluoride, polytetrafluoroethylene, copolymers of the foregoing, and mixtures thereof; and

at least one polyolefinic microporous layer having a porosity in the range of 20-80%, an average pore size in the range of 0.02 to 2 microns, and a Gurley Number in the range of 15 to 150 sec.]

[**8**. The separator according to claim **7** wherein said inorganic particles have an average particle size in the range of 0.001 to 24 microns.]

[**9**. The separator according to claim **7** wherein said inorganix particles are selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, and mixtures thereof.]

[**10**. The separator according to claim **7** wherein said matrix material is selected from the group consisting of polyvinylidene fluoride and/or polyethylene oxide, their copolymers, and mixtures thereof.]

[**11**. A high energy rechargeable lithium battery comprising:

an anode containing lithium metal or lithium-alloy or a mixtures of lithium metal and/or lithium alloy and another material;

a cathode;

a separator according to claims **1-10** disposed between said anode and said cathode; and

an electrolyte in ionic communication with said anode and said cathode via said separator.]

12. A separator for an energy storage system comprises:

at least one ceramic composite layer or coating, said layer including a mixture of 20-95% by weight of inorganic particles selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, TiO_2, SiS_2, $SiPO_4$, [and the like] and mixtures thereof, and 5-80% by weight of a matrix material selected from the group consisting of polyethylene oxide, polyvinylidene fluoride, polytetrafluoroethylene, copolymers of the foregoing, and mixtures thereof, said layer being adapted to at least block dendrite growth and to prevent electronic shorting; and

at least one polyolefinic microporous layer having a porosity in the range of 20-80%, an average pore size in the range of 0.02 to 2 microns, and a Gurley Number in the range of 15 to 150 sec, said layer being adapted to block ionic flow between an anode and a cathode.

13. A separator for a rechargeable lithium battery comprising:

at least one ceramic composite layer wherein the ceramic composite layer includes a mixture of inorganic particles in a matrix material and wherein the ceramic composite layer is adapted to at least block dendrite growth after repetitive charge-discharge cycling and to prevent electronic shorting, wherein the ceramic composite layer is nonporous such that pores are formed once in contact with an electrolyte; and

at least one polyolefinic microporous layer wherein the layer is adapted to block ionic flow between an anode and a cathode.

14. The separator according to claim 13 wherein the ceramic composite layer is a coating.

15. The separator according to claim 14 wherein the coating thickness is in the range of about 0.01 to 25 microns.

16. The separator according to claim 13 wherein the matrix material comprises polyethylene oxide (PEO), polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), polyurethane, polyacrylonitrile (PAN), polymethylmethacrylate (PMMA), polytetraethylene glycol diacrylate, copolymers thereof, or mixtures thereof.

17. The separator according to claim 16 wherein the matrix material comprises polyvinylidene fluoride (PVDF), polyethylene oxide (PEO), copolymers thereof, or mixtures thereof.

18. The separator according to claim 13 wherein the matrix material comprises a gel forming polymer.

19. The separator according to claim 13 wherein the matrix material is a continuous material in which the inorganic particles are embedded.

20. The separator according to claim 13 wherein the inorganic particles have an average particle size in the range of 0.001 to 24 microns.

21. The separator according to claim 13 wherein the inorganic particles comprise silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), calcium carbonate ($CaCO_3$), titanium dioxide (TiO_2), SiS_2, $SiPO_4$, or mixtures thereof.

22. The separator according to claim 13 wherein the inorganic particles comprise silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), calcium carbonate ($CaCO_3$), or mixtures thereof.

23. The separator according to claim 13 wherein the polyolefinic microporous layer comprises polyethylene or polypropylene.

24. The separator according to claim 13 wherein the polyolefinic microporous layer is a polyolefinic membrane.

25. The separator according to claim 24 wherein the polyolefinic membrane is a polyethylene membrane.

26. The separator according to claim 13 wherein the ceramic composite layer prevents electronic shorting by eliminating soft shorts caused by dendrites.

27. The separator according to claim 13 wherein the ceramic composite layer prevents electronic shorting by eliminating soft shorts caused by dendrites that grow during repetitive charge-discharge cycling.

28. A separator for a rechargeable lithium battery comprising:

at least one ceramic composite layer, wherein the ceramic composite layer comprises:

a mixture of about 20-95% by weight of inorganic particles, and

about 5-80% by weight of a matrix material,

wherein the ceramic composite layer is adapted to at least block dendrite growth after repetitive charge-discharge cycling and thereby to prevent electronic shorting and the ceramic composite layer is nonporous such that pores are formed once in contact with an electrolyte; and

at least one polyolefinic microporous layer having a porosity in the range of about 20-80%, an average pore size in the range of about 0.02 to 2 microns, and

wherein the polyolefinic microporous layer is adapted to block ionic flow between an anode and a cathode.

29. The separator according to claim 28 wherein the ceramic composite layer is a coating.

30. The separator according to claim 29 wherein the coating thickness is in the range of about 0.01 to 25 microns.

31. The separator according to claim 28 wherein the matrix material comprises polyethylene oxide (PEO), polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), polyurethane, polyacrylonitrile (PAN), polymethylmethacrylate (PMMA), polytetraethylene glycol diacrylate, copolymers thereof, or mixtures thereof.

32. The separator according to claim 31 wherein the matrix material comprises polyvinylidene fluoride (PVDF), polyethylene oxide (PEO), copolymers thereof, or mixtures thereof.

33. The separator according to claim 28 wherein the matrix material comprises a gel forming polymer.

34. The separator according to claim 28 wherein the matrix material is a continuous material in which the inorganic particles are embedded.

35. The separator according to claim 28 wherein the inorganic particles have an average particle size in the range of about 0.001 to 24 microns.

36. The separator according to claim 28 wherein the inorganic particles comprise silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), calcium carbonate ($CaCO_3$), titanium dioxide (TiO_2), SiS_2, $SiPO_4$, or mixtures thereof.

37. The separator according to claim 36 wherein the inorganic particles comprise silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), calcium carbonate ($CaCO_3$), or mixtures thereof.

38. The separator according to claim 28 wherein the ceramic composite layer prevents electronic shorting by eliminating soft shorts caused by dendrites.

39. The separator according to claim 28 wherein the ceramic composite layer prevents electronic shorting by eliminating soft shorts caused by dendrites that grow during repetitive charge-discharge cycling.

* * * * *

EXHIBIT B

US006692867B2

(12) **United States Patent**
Nark et al.

(10) **Patent No.: US 6,692,867 B2**
(45) **Date of Patent: Feb. 17, 2004**

(54) **BATTERY SEPARATOR-PIN REMOVAL**

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(73) Assignee: **Celgard Inc.**, Charlotte, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 129 days.

(21) Appl. No.: **09/976,982**

(22) Filed: **Oct. 12, 2001**

(65) **Prior Publication Data**

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(51) **Int. Cl.**[7] **H01M 2/16**
(52) **U.S. Cl.** **429/142**; 429/144; 429/254
(58) **Field of Search** 429/129, 142, 429/144, 247, 249, 250, 254; 508/459

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(57) **ABSTRACT**

A method for removing a pin from a battery assembly by the step of providing a separator comprising: a microporous membrane having an exterior surface portion of polypropylene, the polypropylene including at least 50 ppm of metallic stearate, preferably calcium stearate Static and being adapted to exhibit a pin removal force ≦7100 g.

20 Claims, No Drawings

BATTERY SEPARATOR-PIN REMOVAL

FIELD OF THE INVENTION

The instant invention is directed to a battery separator having improved pin removal properties.

BACKGROUND OF THE INVENTION

In the manufacture of high energy, lightweight batteries, for example, secondary lithium batteries, the battery assembly, i.e., an anode tape and a cathode tape sandwiching a separator tape, is wound about one (1) or more pins (or cores or mandrels) . To begin winding of the assembly, the separator tape is taken up on the pin, and then the anode and cathode tapes are fed to the pin. Upon completion of the winding, the battery assembly is removed (or withdrawn) from the pin. If the assembly (i.e., the separator tape) sticks on the pin during withdrawal, the assembly "telescopes" and must be rejected. Such rejects increase the cost of the battery manufacturing process. Accordingly, battery manufacturers desire separator tapes that have improved pin removal properties, i.e., separators that will not stick to the pin when the battery assembly is removed therefrom.

Several attempts have been made to solve the foregoing pin removal problem. In Japanese Kokai 10-110052 published Apr. 28, 1998, the surface of a microporous membrane is textured to improve the pin removal. Spherical particles, consisting of an organic resin, preferably at least one resin selected from fluororesins and silicone resins, protrude from the membranes surface. The textured surface reduces frictional resistance. In Japanese Kokai 10-139918 published May 26, 1998, the surface of a microporous membrane is coated with a lubricant to improve pin removal. The coating may be accomplished by dip coating or roll coating. The lubricants include (waxes e.g., paraffin wax, microcrystalline wax, low-molecular weight polyethylene and other hydrocarbons waxes); fatty acid esters (e.g., methyl stearate, stearyl stearate, monoglyceride stearate); aliphatic amides (e.g., stearamide, palmitamide, methylene bis stearamide), and combinations thereof. In Japanese Kokai 10-195215 published Jul. 28, 1998, the surface portion of the microporous membrane, which has a greater ratio of polyethylene to polypropylene than the middle portion of the membrane, has improved pin removal properties. In U.S. patent application Ser. No. 09/661,519 filed Sep. 13, 2000, the surface of the pin is modified to improve pin removal. The surface modifications include texturing (roughing) the surface and/or grooving the surface of the pin.

The use of calcium stearate as an additive in polyolefin resins is known. See: *Plastics Engineering Handbook*, Chapman & Hall, New York City, N.Y., (1991), p. 645. Therein, it is noted that calcium stearate, when used in polyolefins, acts to 'tie up catalyst,' that lubricants are used to enhance resin processibility, and that 'effective lubricants . . . do not adversely affect the properties of end products' (i.e., they are inert). For example, 600 ppm of calcium stearate has been added to polypropylene for the purpose of acting as an acid scavenger. See Witco's Additive Product Guide, Polymer Additives Group, Olefins/Styrenics, page 2. Calcium stearate may also act as a lubricant to improve the flow characteristics of the polyolefin resins. Witco, Ibid., page 2. Polypropylene resins containing calcium stearate have been used to make battery separators, i.e., CELGARD® 2400, a single layer polypropylene separator, and CELGARD® 2300, a multilayered separator.

In spite of the foregoing efforts, there is still a need to improve the pin removal properties of these separators.

SUMMARY OF THE INVENTION

A method for removing a pin from a battery assembly comprising the step of providing a separator comprising:

a microporous membrane having an exterior surface portion of polypropylene, the polypropylene including at least 50 ppm of metallic stearate and being adapted to exhibit a pin removal force ≦7100 g.

DESCRIPTION OF THE INVENTION

A microporous membrane, as used herein, has a plurality of micropores that extend through the membrane. The micropores have an average pore size ranging from 0.005 to 10 microns, preferably 0.01 to 5 microns, and most preferably 0.05 to 2 microns. The microporous membrane also has a Gurley (ASTM D726B) ranging from 5 to 100 seconds, preferably 10–60 seconds. Preferably, these membranes are "shutdown membranes," i.e., having the ability to stop ion flow between the anode and cathode upon the onset of a rapid increase in the battery's temperature due to, for example, internal short circuiting. The microporous membrane may be a single ply membrane or a multilayered membrane, as is well understood in the art. The preferred multilayered structure has a polypropylene/polyethylene/polypropylene structure (PP/PE/PP). The preferred single ply membrane is made from polypropylene. The exterior surface portion of the membrane (a coined term that refers to the surface of either a single ply or multi ply membrane) is preferably a polypropylene. The polypropylene is preferably an isotactic polypropylene homopolymer. Such polypropylene has a melt flow index (MFI) ranging from 1 to 4, preferably, 1.2 to 1.7. Such polypropylene has a density ranging from 0.90 to 0.91 g/cm^3. Preferably, these membrane's are produced by an 'extrude, anneal, stretch' method (a/k/a the 'dry stretch' or the Celgard® method), but may include other techniques such as 'solvent extraction.' See: Kesting, R., *Synthetic Polymeric Membranes*, John Wiley and Sons, New York City, N.Y. (1985), incorporated herein by reference.

It has been determined that the pin removal properties of the separator are improved by the inclusion of a metallic stearate in the polypropylene exterior surface portion of the membrane, preferably at least 50 ppm of the metallic stearate. The preferred metallic stearate is calcium stearate. Preferably, the calcium stearate in the polypropylene is at least 50 ppm, preferably 50–3000 ppm, and most preferred, between 300 and 600 ppm. The amount of calcium stearate was determined by induced coupled plasma (ICP) analysis. The lower limit defines the minimum amount of metallic stearate needed to obtain the improved pin removal properties. The upper limit defines the maximum amount of the metallic stearate tolerable before the risk, that the metallic stearate will dissolve from the separator in to the electrolyte and thereby adversely impact the electrochemical properties of the electrolyte, becomes to great. Such calcium stearates are commercially available from Witco Corporation, Greenwich, Conn. under the tradename of 'Calcium Stearate Regular.'

The present invention will be further explained with reference to the examples set forth below.

The pin removal properties were quantified using the following procedure that measures the 'pin removal force (g).'

A battery winding machine was used to wind the separator around a pin (or core or mandrel). The pin is a two (2) piece cylindrical mandrel with a 0.16 inch diameter and a smooth

exterior surface. Each piece has a semicircular cross section. The separator, discussed below, is taken up on the pin. The initial force (tangential) on the separator is 0.5 kgf and thereafter the separator is wound at a rate of ten (10) inches in twenty four (24) seconds. During winding, a tension roller engages the separator being wound on the mandrel. The tension roller comprises a ⅝" diameter roller located on the side opposite the separator feed, a ¾" pneumatic cylinder to which 1 bar of air pressure is applied (when engaged), and a ¼" rod interconnecting the roller and the cylinder.

The separator consists of two (2) 30 mm (width)×10" pieces of the membrane being tested. Five (5) of these separators are tested, the results averaged, and the averaged value is reported. Each piece is spliced onto a separator feed roll on the winding machine with a 1" overlap. From the free end of the separator, i.e., distal the spliced end, ink marks are made at ½" and 7". The ½" mark is aligned with the far side of the pin (i.e., the side adjacent the tension roller), the separator is engaged between the pieces of the pin, and winding is begun with the tension roller engaged. When the 7" mark is about ½" from the jellyroll (separator wound on the pin), the separator is cut at that mark, and the free end of the separator is secured to the jellyroll with a piece of adhesive tape (1" wide, ½" overlap). The jellyroll (i.e., pin with separator wound thereon) is removed from the winding machine. An acceptable jellyroll has no wrinkles and no telescoping.

The jellyroll is placed in a tensile strength tester (i.e., Chatillon Model TCD 500-MS from Chatillon Inc., Greensboro, N.C.) with a load cell (50 lbs×0.02 lb; Chatillon DFGS 50). The strain rate is 2.5 inches per minute and data from the load cell is recorded at a rate of 100 points per second. The peak force is reported as the pin removal force.

Gurley was measured according to ASTM-D726(B). COF (Coefficient of friction) Static was measured according to JIS P 8147 entitled "Method for Determining Coefficient of Friction of Paper and Board."

EXAMPLES

In Table 1, samples C1–C2 and 1–2 are single layer polypropylene microporous membranes. C1 and C2 were commercially available membranes (prior art, PA) sold under the name CELGARD® 2400. Samples 1 and 2 illustrate the present invention. Each of these samples was extruded through a circular die at 200° C., annealed at 150° C. with 6% stretch, and stretched, i.e., cold stretch 16–18%, and hot stretch with relax to the amount shown in the table.

TABLE 1

	C1 (PA)	C2 (PA)	1	2
Resin	PP	PP	PP	PP
MFI	1.2	1.2	1.2	1.2
Total Thickness mil	1	1	1	1
Gurley 10 cc/sec	24	24	24	24
Porosity %	40	40	40	40
Total Stretch %	100	100	100	100
Calcium Stearate ppm	340	<1	250	1545
Pin Removal Force (g)	6500	7200	6700	6600
Avg COF STATIC	0.36	0.46	0.42	0.36

In Table 2, samples C3, C4, and 3 are multilayered (PP/PE/PP) microporous membranes. C3 and C4 were commercially available products, CELGARD® 2300 and CELGARD® E162, respectively. Sample 3 illustrates the present invention. All thin layer PP was extruded on a circular die at 224° C. All trilayers were annealed (125° C.) and bonded (133° C.) with 11% stretch. Then, the film was cold stretched at 20–25% and hot stretched and relaxed for the total stretch listed in Table 2.

TABLE 2

	C3 (PA)	C4 (PA)	3
Resin	PP	PP	PP
MFI	1.2	1.2	1.2
Total Thickness mil	1	1	1
PP layer Thickness mil	0.36	0.36	0.36
Gurley 10 cc/sec	24	24	24
Porosity %	40	40	40
Total Stretch %	109	109	109
Calcium Stearate ppm	492	<1	584
Pin Removal Force (g)	6900	7300	6100
Avg COF STATIC	0.56	0.58	

In Table 3, samples C5, and 4 are multilayered (PP/PE/PP) microporous membranes. C5 was a commercially available product (prior art (PA)), CELGARD® 2320. Sample 4 illustrates the present invention. All thin layer PP was extruded on a circular die at 224° C. All trilayers were annealed (125° C.) and bonded (133° C.) with 11% stretch. Then, the film was cold stretched at 20–25% and hot stretched and relaxed for the total stretch listed in Table 3.

TABLE 3

	C5 (PA)	4
Resin	PP	PP
MFI	1.2	1.2
Total Thickness mil	0.78	0.78
PP layer Thickness mil	0.24	0.24
Gurley 10 cc/sec	20	20
Porosity %	43	43
Total Stretch %	122	122
Calcium Stearate ppm	<1	428
Pin Removal Force (g)	8300	6900
Avg COF STATIC	0.41	0.46

The present invention made be embodied in other forms without departing from the spirit and the central attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicated the scope of the invention.

What is claimed is:

1. A method for removing a pin from a battery assembly comprising the step of:

providing a battery assembly having a separator engaging a pin, said separator comprising a microporous membrane having an exterior surface portion of polypropylene, the polypropylene including at least 50 ppm of a calcium stearate; and

removing the pin from the battery assembly.

2. The method of claim **1** wherein the calcium stearate ranges between 50 and 3000 ppm of the polypropylene.

3. The method according to claim **1** wherein the microporous membrane further comprises a plurality of micropores therethrough, said micropores having an average pore size ranging from 0.05 to 10 microns, and said membrane having a Gurley ranging from 5 to 100 seconds.

4. The method of claim **1** wherein the membrane further comprises a multilayered membrane having a polypropylene-polyethylene-polypropylene structure.

5. The method according to claim **4** being a shut-down separator.

6. The method of claim **1** wherein the polypropylene comprising a polypropylene with a melt flow index between 1 and 4.

7. The method of claim **6** wherein the polypropylene is a polypropylene with a melt flow index between 1.2 and 1.7.

8. A method for removing a pin from a battery assembly comprising the step of:

providing a battery assembly having a separator engaging a pin, said separator comprising a microporous membrane having an exterior surface portion of polypropylene, the polypropylene including at least 50 ppm of a metallic stearate, and the membrane having a thickness of ≦1 mil (25 microns) and a pin removal force ≦7100 g; and

removing the pin from the battery assembly.

9. The method of claim **8** wherein the metallic stearate is a calcium stearate.

10. The method of claim **9** wherein the calcium stearate ranges between 50 and 3000 ppm of the polypropylene.

11. The method of claim **9** wherein the calcium stearate ranges between 300 and 600 ppm of the polypropylene.

12. The method according to claim **8** wherein the microporous membrane further comprises a plurality of micropores therethrough, said micropores having an average pore size ranging from 0.05 to 10 microns, and said membrane having a Gurley ranging from 5 to 100 seconds.

13. The method of claim **8** wherein the membrane further comprises a multilayered membrane having a polypropylene-polyethylene-polypropylene structure.

14. The method according to claim **13** being a shut-down separator.

15. The method of claim **8** wherein the polypropylene comprising a polypropylene with a melt flow index between 1 and 4.

16. The method of claims **15** wherein the polypropylene is a polypropylene with a melt flow index between 1.2 and 1.7.

17. A battery separator with improved pin removal properties comprising:

a microporous membrane having a polypropylene surface portion including at least 50 ppm of a metallic stearate.

18. The battery separator according to claim **17** wherein said metallic stearate being a calcium stearate ranging from 50 to 3000 ppm.

19. The battery separator according to claim **17** wherein said polypropylene having a melt flow index between 1 and 4.

20. The battery separator according to claim **17** having a pin removal force ≦7100 g.

* * * * *

EXHIBIT C

US006432586B1

(12) United States Patent
Zhang

(10) Patent No.: US 6,432,586 B1
(45) Date of Patent: Aug. 13, 2002

(54) **SEPARATOR FOR A HIGH ENERGY RECHARGEABLE LITHIUM BATTERY**

(75) Inventor: **Zhengming Zhang**, Charlotte, NC (US)

(73) Assignee: **Celgard Inc.**, Charlotte, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/546,266**

(22) Filed: **Apr. 10, 2000**

(51) **Int. Cl.**[7] **H01M 2/16**

(52) **U.S. Cl.** **429/251**; 429/247; 429/248; 429/249; 429/252; 429/231.95

(58) **Field of Search** 429/247, 248, 429/249, 251, 252, 231.95

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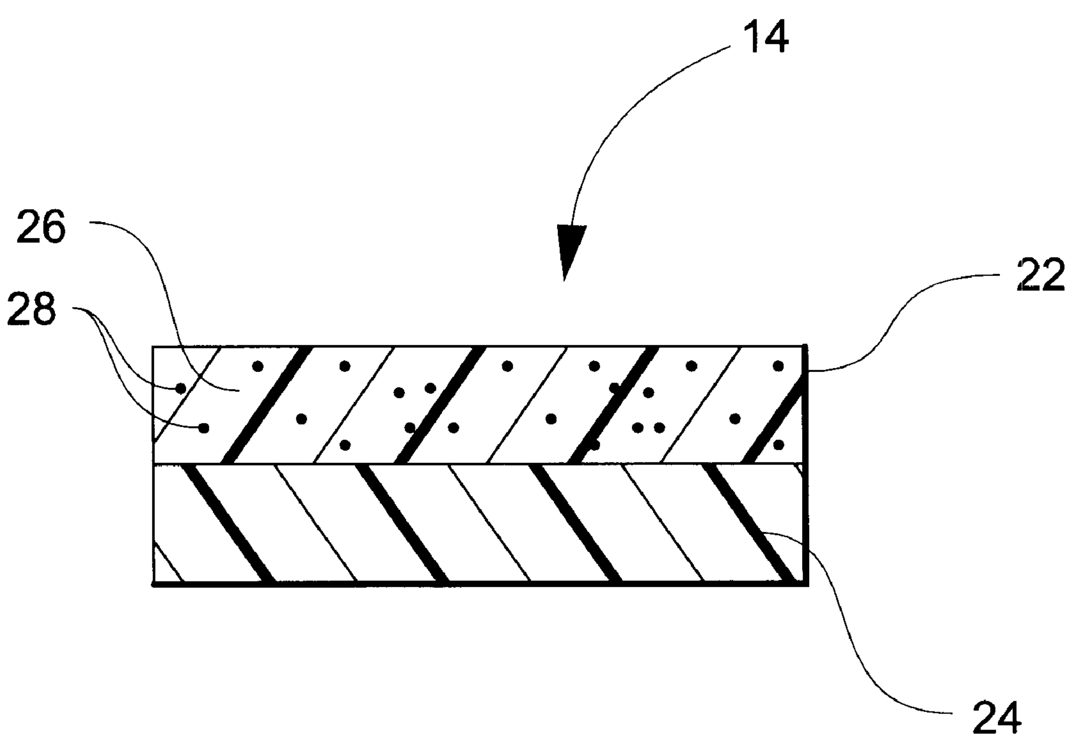
Primary Examiner—Patrick Ryan
Assistant Examiner—Angela J Martin
(74) *Attorney, Agent, or Firm*—Robert H. Hammer, III

(57) **ABSTRACT**

The instant invention is directed to a separator for a high energy rechargeable lithium battery and the corresponding battery. The separator includes a ceramic composite layer and a polymeric microporous layer. The ceramic layers includes a mixture of inorganic particles and a matrix material. The ceramic layer is adapted, at least, to block dendrite growth and to prevent electronic shorting. The polymeric layer is adapted, at least, to block ionic flow between the anode and the cathode in the event of thermal runaway.

12 Claims, 1 Drawing Sheet



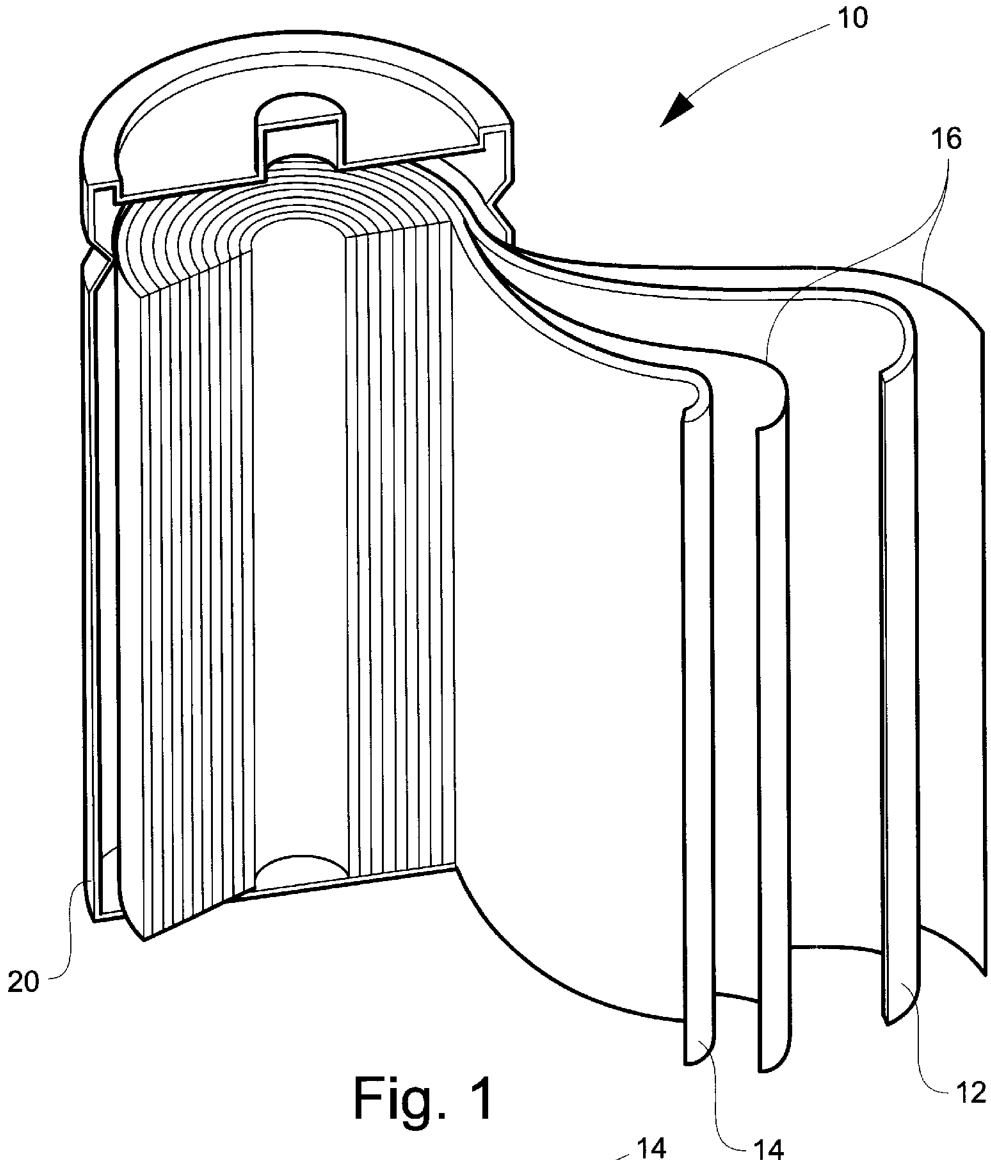


Fig. 1

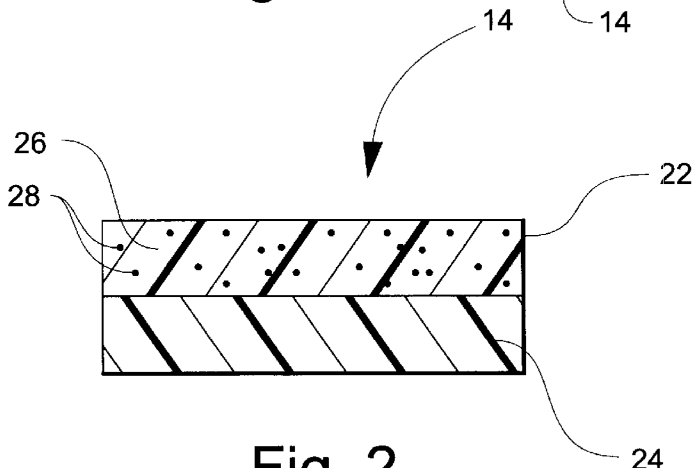


Fig. 2

SEPARATOR FOR A HIGH ENERGY RECHARGEABLE LITHIUM BATTERY

FIELD OF THE INVENTION

A separator for a high energy rechargeable lithium battery and a high energy rechargeable lithium battery are disclosed herein.

BACKGROUND OF THE INVENTION

A high energy rechargeable lithium battery has an anode with an energy capacity of at least 372 milliampere-hours/gram (mAh/g). Such anodes include, for example, lithium metal, lithium alloys (e.g. lithium aluminum), and mixtures of lithium metal or lithium alloys and materials such as carbon, nickel, and copper. Such anodes exclude anodes solely with lithium intercalation or lithium insertion compounds.

The commercial success of lithium metal or lithium alloy batteries has eluded all but primary cells due to persistent safety problems.

The difficulties associated with the use of the foregoing anodes stem mainly from lithium dendrite growth that occurs after repetitive charge-discharge cycling. (While dendrite growth is a potential problem with any lithium battery, the severity of the problem with the above-mentioned high energy anodes is much greater than with other lithium anodes (e.g. pure carbon intercalation anodes) as is well known in the art.) When lithium dendrites grow and penetrate the separator, an internal short circuit of the battery occurs (any direct contact between anode and cathode is referred to as "electronic" shorting, and contact made by dendrites is a type of electronic shorting). Some shorting (i.e., a soft short), caused by very small dendrites, may only reduce the cycling efficiency of the battery. Other shorting may result in thermal runaway of the lithium battery, a serious safety problem for lithium rechargeable battery.

The failure to control the dendrite growth from such anodes remains a problem, limiting the commercialization of cells with those anodes, particularly those cells with liquid organic electrolytes.

Accordingly, there is a need to improve high energy rechargeable lithium batteries.

SUMMARY Of THE INVENTION

The instant invention is directed to a separator for a high energy rechargeable lithium battery and the corresponding battery. The separator includes at least one ceramic composite layer and at least one polymeric microporous layer. The ceramic composite layer includes a mixture of inorganic particles and a matrix material. The ceramic composite layer is adapted, at least, to block dendrite growth and to prevent electronic shorting. The polymeric layer is adapted, at least, to block ionic flow between the anode and the cathode in the event of thermal runaway.

DETAILED DESCRIPTION OF THE DRAWINGS

For the purpose of illustrating the invention, there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is a sectional view of a lithium metal battery.

FIG. **2** is a cross-sectional view of the separator.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the figures, wherein like numerals indicate like elements, there is shown in FIG. **1** a lithium metal battery (or cell) **10**. Lithium metal cell **10** comprises a lithium metal anode **12**, a cathode **14**, and a separator **16** disposed between anode **12** and cathode **14**, all of which is packaged within a can **20**. The illustrated cell **10** is a cylindrical cell or 'jelly roll' cell, but the invention is not so limited. Other configurations, for example, prismatic cells, button cells, or polymer cells are also included. Additionally, not shown is the electrolyte. The electrolyte may be a liquid (organic or inorganic), or a gel (or polymer). The invention will be, for convenience, described with regard to a c ylindrical cell with a liquid organic electrolyte, but it is not so limited and may find use in other cell types (e.g. energy storage system, combined cell and capacitor) and configurations.

The anode **12** should have an energy capacity greater than or equal to 372 mAh/g, preferably $\geqq$700 mAh/g, and most preferably $\geqq$1000 mAH/g. Anode **12** may be constructed from a lithium metal foil or a lithium alloy foil (e.g. lithium aluminum alloys), or a mixture of a lithium metal and/or lithium alloy and materials such as carbon (e.g. coke, graphite), nickel, copper. The anode **12** is not made solely from intercalation compounds containing lithium or insertion compounds containing lithium.

The cathode **14** may be any cathode compatible with the anode and may include an intercalation compound, an insertion compound, or an electrochemically active polymer. Suitable intercalation materials includes, for example, MoS_2, FeS_2, MnO_2, TiS_2, $NbSe_3$, $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$, V_6O_{13}, V_2O_5, and $CuCl_2$. Suitable polymers include, for example, polyacetylene, polypyrrole, polyaniline, and polythiopene.

The electrolyte may be liquid or gel (or polymer). Typically, the electrolyte primarily consists of a salt and a medium (e.g. in a liquid electrolyte, the medium may be referred to as a solvent; in a gel electrolyte, the medium may be a polymer matrix). The salt may be a lithium salt. The lithium salt may include, for example, $LiPF_6$, $LiAsF_6$, $LiCF_3SO_3$, $LiN(CF_3SO_3)_3$, $LiBF_6$, and $LiClO_4$, BETTE electrolyte (commercially available from 3M Corp. of Minneapolis, MN) and combinations thereof. Solvents may include, for example, ethylene carbonate (EC), propylene carbonate (PC), EC/PC, 2-MeTHF(2-methyltetrahydrofuran)/EC/PC, EC/DMC (dimethyl carbonate), EC/DME (dimethyl ethane), EC/DEC (diethyl carbonate), EC/EMC (ethylmethyl carbonate), EC/EMC/DMC/DEC, EC/EMC/DMC/DEC/PE, PC/DME, and DME/PC. Polymer matrices may include, for example, PVDF (polyvinylidene fluoride), PVDF:THF (PVDF:tetrahydrofuran), PVDF:CTFE (PVDF: chlorotrifluoro ethylene) PAN (polyacrylonitrile), and PEO (polyethylene oxide).

Referring to FIG. **2**, separator **16** is shown. Separator **16** comprises a ceramic composite layer **22** and a polymeric microporous layer **24**. The ceramic composite layer is, at least, adapted for preventing electronic shorting (e.g. direct or physical contact of the anode and the cathode) and blocking dendrite growth. The polymeric microporous layer is, at least, adapted for blocking (or shutting down) ionic conductivity (or flow) between the anode and the cathode during the event of thermal runaway. The ceramic composite layer **22** of separator **16** must be sufficiently conductive to allow ionic flow between the anode and cathode, so that current, in desired quantities, may be generated by the cell. The layers **22** and **24** should adhere well to one another, i.e. separation should not occur. The layers **22** and **24** may be formed by lamination, coextrusion, or coating processes. Ceramic composite layer **22** may be a coating or a discrete

layer, either having a thickness ranging from 0.001 micron to 50 microns, preferably in the range of 0.01 micron to 25 microns. Polymeric microporous layer **24** is preferably a discrete membrane having a thickness ranging from 5 microns to 50 microns, preferably in the range of 12 microns to 25 microns. The overall thickness of separator **16** is in the range of 5 microns to 100 microns, preferably in the range of 12 microns to 50 microns.

Ceramic composite layer **22** comprises a matrix material **26** having inorganic particles **28** dispersed therethrough. Ceramic composite layer **22** is nonporous (it being understood that some pores are likely to be formed once in contact with an electrolyte, but ion conductivity of layer **22** is primarily dependent upon choice of the matrix material **26** and particles **28**). The matrix material **26** of layer **22** differs from the foregoing polymer matrix (i.e., that discussed above in regard to the medium of the electrolyte) in, at least, function. Namely, matrix material **26** is that component of a separator which, in part, prevents electronic shorting by preventing dendrite growth; whereas, the polymer matrix is limited to the medium that carries the dissociated salt by which current is conducted within the cell. The matrix material **26** may, in addition, also perform the same function as the foregoing polymer matrix (e.g. carry the electrolyte salt). The matrix material **26** comprises about **5-80**% by weight of the ceramic composite layer **22**, and the inorganic particles **28** form approximately 20–95% by weight of the layer **22**. Preferably, composite layer **22** contains inorganic particles 30%–75% by weight. Most preferably, composite layer **22** contains inorganic particles 40%–60% by weight.

The matrix material **26** may be ionically conductive or non-conductive, so any gel forming polymer suggested for use in lithium polymer batteries or in solid electrolyte batteries may be used. The matrix material **26** may be selected from, for example, polyethylene oxide (PEO), polyvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), polyurethane, polyacrylonitrile (PAN), polymethylmethacrylate (PMMA), polytetraethylene glycol diacrylate, copolymers thereof, and mixtures thereof. The preferred matrix material is PVDF and/or PEO and their copolymers. The PVDF copolymers include PVDF:HFP (polyvinylidene fluoride:hexafluoropropylene) and PVDF:CTFE (polyvinylidene fluoride:chlorotrifluoroethylene). Most preferred matrix materials include PVDF:CTFE with less than 23% by weight CTFE, PVDH:HFP with less than 28% by weight HFP, any type of PEO, and mixtures thereof.

The inorganic particles **28** are normally considered nonconductive, however, these particles, when in contact with the electrolyte, appear, the inventor, however, does not wish to be bound hereto, to develop a superconductive surface which improves the conductivity (reduces resistance) of the separator **16**. The inorganic particles **28** may be selected from, for example, silicon dioxide (SiO_2), aluminum oxide (Al_2O_3), calcium carbonate ($CaCO_3$), titanium dioxide (TiO_2), SiS_2, $SiPO_4$ and the like, or mixtures thereof. The preferred inorganic particle is SiO_2, Al_2O_3, and $CaCO_3$. The particles may have an average particle size in the range of 0.001 micron to 25 microns, most preferably in the range of 0.01 micron to 2 microns.

The microporous polymeric layer **24** consists of any commercially available microporous membranes (e.g. single ply or multi-ply), for example, those products produced by Celgard Inc. of Charlotte, North Carolina, Asahi Chemical of Tokyo, Japan, and Tonen of Tokyo, Japan. The layer **24** has a porosity in the range of 20–80%, preferably in the range of 28–60%. The layer **24** has an average pore size in the range of 0.02 to 2 microns, preferably in the range of 0.08 to 0.5 micron. The layer **24** has a Gurley Number in the range of 15 to 150 sec, preferably 30 to 80 sec. (Gurley Number refers to the time it takes for 10 cc of air at 12.2 inches of water to pass through one square inch of membrane.) The layer **24** is preferably polyolefinic. Preferred polyolefins include polyethylene and polypropylene. Polyethylene is most preferred.

The foregoing separator, while primarily designed for use in high energy rechargeable lithium batteries, may be used in other battery systems in which dendrite growth may be a problem.

The foregoing shall be further illustrated with regard to the following non-limiting examples.

EXAMPLES

Sixty (60) parts of fine particle calcium carbonate, 40 parts of PVDF:HFP (Kynar 2801), are dissolved in 100 parts of acetone at 35° C. for 3 hours under high shear mixing. The solution is cast into a 15 micron film. After vaporization of the actone at room temperature, the composite film was thermally laminated with 2 layers (8 microns) of Celgard 2801 membrane. The resulting composite shutdown separator has a structure of PE/composite/PE and a thickness of 30 microns.

Thirty (30) parts of silicon dioxide, 30 parts of calcium carbonate, 40 parts of PVDF:HFP (Kynar 2801) are dissolved in 100 parts of acetone at 35° C. for 3 hours under high shear mixing. This solution was cast or coated onto a 23 micron layer of a polyethylene microporous layer made by Celgard Inc. After vaporization of the acetone at room temperature, the polyethylene/composite membrane had a thickness of 38 microns.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicating the scope of the invention.

What is claimed is:

1. A separator for a high energy rechargeable lithium battery comprises:

at least one ceramic composite layer, said layer including a mixture of inorganic particles in a matrix material; said layer being adapted to at least block dendrite growth and to prevent electronic shorting; and

at least one polyolefinic microporous layer, said layer being adapted to block ionic flow between an anode and a cathode.

2. The separator according to claim **1** wherein said mixture comprises between 20% to 95% by weight of said inorganic particles and between 5% to 80% by weight of said matrix material.

3. The separator according to claim **1** wherein said inorganic particles are selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, TiO_2, SiS_2, $SiPO_4$ and the like, and mixtures thereof.

4. The separator according to claim **1** wherein said matrix material is selected from the group consisting of polyethylene oxide, polyvinylidene fluoride, polytetrafluoroethylene, polyurethane, polyacrylonitrile, polymethylmethacrulate, polytetraethylene glycol diacrylate, copolymers thereof, and mixtures thereof.

5. The separator according to claim **1** wherein said polyolefinic microporous layer is a polyolefinic membrane.

6. The separator according to claim **5** wherein said polyolefinic membrane is a polyethylene membrane.

7. A separator for a high energy rechargeable lithium battery comprises:

at least one ceramic composite layer or coating, said layer including a mixture of 20–95% by weight of inorganic particles selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, TiO_2, SiS_2, $SiPO_4$ and the like, and mixtures thereof, and 5–80% by weight of a matrix material selected from the group consisting of polyethylene oxide, polyvinylidene fluoride, polytetrafluoroethylene, copolymers of the foregoing, and mixtures thereof; and

at least one polyolefinic microporous layer having a porosity in the range of 20–80%, an average pore size in the range of 0.02 to 2 microns, and a Gurley Number in the range of 15 to 150 sec.

8. The separator according to claim **7** wherein said inorganic particles have an average particle size in the range of 0.001 to 24 microns.

9. The separator according to claim **7** wherein said inorganix particles are selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, and mixtures thereof.

10. The separator according to claim **7** wherein said matrix material is selected from the group consisting of polyvinylidene fluoride and/or polyethylene oxide, their copolymers, and mixtures thereof.

11. A high energy rechargeable lithium battery comprising:

an anode containing lithium metal or lithium-alloy or a mixtures of lithium metal and/or lithium alloy and another material;

a cathode;

a separator according to claims **1–10** disposed between said anode and said cathode; and

an electrolyte in ionic communication with said anode and said cathode via said separator.

12. A separator for an energy storage system comprises:

at least one ceramic composite layer or coating, said layer including a mixture of 20–95% by weight of inorganic particles selected from the group consisting of SiO_2, Al_2O_3, $CaCO_3$, TiO_2, SiS_2, $SiPO_4$ and the like, and mixtures thereof, and 5–80% by weight of a matrix material selected from the group consisting of polyethylene oxide, polyvinylidene fluoride, polytetrafluoroethylene, copolymers of the foregoing, and mixtures thereof, said layer being adapted to at least block dendrite growth and to prevent electronic shorting; and

at least one polyolefinic microporous layer having a porosity in the range of 20–80%, an average pore size in the range of 0.02 to 2 microns, and a Gurley Number in the range of 15 to 150 sec, said layer being adapted to block ionic flow between an anode and a cathode.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,432,586 B1
APPLICATION NO. : 09/546266
DATED : August 13, 2002
INVENTOR(S) : Zhengming Zhang

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims:

Column 4, line 54 (in claim 3): delete “and the like”.

Column 5, line 4 (in claim 7): delete “and the like”.

Column 6, line 12 (in claim 12): delete “and the like”.

Signed and Sealed this
Twenty-third Day of April, 2013

Teresa Stanek Rea
Acting Director of the United States Patent and Trademark Office

(12) **INTER PARTES REVIEW CERTIFICATE** (1066th)

United States Patent (10) **Number: US 6,432,586 K1**

Zhang (45) **Certificate Issued: Sep. 14, 2018**

(54) **SEPARATOR FOR A HIGH ENERGY RECHARGEABLE LITHIUM BATTERY**

(75) Inventor: **Zhengming Zhang**

(73) Assignee: **CELGARD, LLC**

Trial Numbers:

IPR2014-00679 filed May 19, 2014
IPR2014-00680 filed May 9, 2014
IPR2014-00692 filed Apr. 25, 2014

Inter Partes Review Certificate for:

Patent No.: **6,432,586**
Issued: **Aug. 13, 2002**
Appl. No.: **09/546,266**
Filed: **Apr. 10, 2000**

The results of IPR2014-00679, IPR2014-00680 and IPR2014-00692 are reflected in this inter partes review certificate under 35 U.S.C. 318(b).

INTER PARTES REVIEW CERTIFICATE
U.S. Patent 6,432,586 K1
Trial No. IPR2014-00679
Certificate Issued Sep. 14, 2018

1

2

AS A RESULT OF THE INTER PARTES REVIEW PROCEEDING, IT HAS BEEN DETERMINED THAT:

Claim **12** is found patentable.

Claims **1-11** are cancelled.

* * * * *

EXHIBIT D

Source: *Polypore International, Inc.*

February 25, 2013 08:06 ET

Celgard Files Patent Infringement Lawsuit

CHARLOTTE, N.C., Feb. 25, 2013 (GLOBE NEWSWIRE) -- Celgard, LLC ("Celgard"), a subsidiary of Polypore International, Inc. (NYSE:PPO), has filed a complaint in the U.S. District Court of the Western District of North Carolina against Sumitomo Chemical Company, Limited.

The complaint alleges that Sumitomo Chemical has infringed Celgard's United States Patent No. 6,432,586 issued for an invention entitled, "Separator for a High Energy Rechargeable Lithium Battery." The patent in the lawsuit covers ceramic composite layer lithium-ion battery separators first developed by Celgard for high-energy rechargeable lithium-ion batteries. This lawsuit has been filed after a period in which Celgard attempted to resolve its concerns with Sumitomo Chemical over infringement of Celgard's patent.

"Celgard has a long history of innovation in lithium-ion battery separators and is a world leader in this technology," said Robert B. Toth, Chairman, President and Chief Executive Officer of Polypore. "We have a responsibility to our customers, partners, and shareholders to safeguard the investments we make in innovation, and therefore will take appropriate steps like this to prevent the knowing and unfair exploitation of our intellectual property."

Celgard is represented by the law firm Kilpatrick Townsend & Stockton, LLP.

About Polypore International, Inc.

Polypore International, Inc. is a global high technology filtration company specializing in microporous membranes. Polypore's flat sheet and hollow fiber membranes are used in specialized applications that require the removal or separation of various materials from liquids, primarily in the ultrafiltration and microfiltration markets. Based in Charlotte, NC, Polypore International, Inc. is a market leader with manufacturing facilities or sales offices in ten countries serving six continents. See www.polypore.net.

Forward-Looking Statement

This release contains statements that are forward-looking in nature. Statements that are predictive in nature, that depend upon or refer to future events or conditions or that include words such as "expects," "anticipates," " intends," "plans," "believes," "estimates," and similar expressions are forward-looking statements. These statements involve known and unknown risks, uncertainties and other factors that may cause our actual results and performance to be materially different from any future results or performance expressed or implied by these forward-looking statements. These factors include the following: the highly competitive nature of the markets in which we sell our products; the failure to continue to develop innovative products; the loss of our customers; the vertical integration by our customers of the production of our products into their own manufacturing process; increases in prices for raw materials or the loss of key supplier contracts; our substantial indebtedness; interest rate risk related to our variable rate indebtedness; our inability to generate cash; restrictions related to the senior

secured credit agreement; employee slowdowns, strikes or similar actions; product liability claims exposure; risks in connection with our operations outside the United States, including compliance with applicable anti-corruption laws; the incurrence of substantial costs to comply with, or as a result of violations of, or liabilities under, environmental laws; the failure to protect our intellectual property; loss of senior management; the incurrence of additional debt, contingent liabilities and expenses in connection with future acquisitions; the failure to effectively integrate newly acquired operations; lithium market demand does not materialize as anticipated; the absence of expected returns from the intangible assets we have recorded;the adverse impact from legal proceedings on our financial condition; and natural disasters, epidemics, terrorist acts and other events beyond our control. Additional information concerning these and other important factors can be found in Item 1A. "Risk Factors" of our most recent Annual Report on Form 10-K and subsequent reports filed with the Securities and Exchange Commission. Such forward-looking statements speak only as of the date of this press release. Polypore expressly disclaims any obligation to release publicly any updates or revisions to any forward-looking statements contained herein to reflect any change in Polypore's expectations with regard thereto or change in events, conditions or circumstances on which any statement is based.

Polypore International, Inc.
Corporate Communications

Beth Kitteringham
(704) 587-8596

Polypore and Sumitomo sign license agreement for battery separator coating

Posted January 4, 2014 by Charles Morris (https://chargedevs.com/author/charles-morris/) & filed under Newswire (https://chargedevs.com/category/newswire/), The Tech (https://chargedevs.com/category/newswire/the-tech/).

Polypore International and Sumitomo Chemical have entered into a Settlement and License Agreement which ends outstanding litigation between the two companies.

Last February, Charlotte-based Polypore's Celgard unit filed a patent-infringement suit against Sumitomo over Celgard's lithium-ion battery separators, which are designed to prevent short circuits and limit safety problems from overheating.

Under the new License Agreement, Sumitomo Chemical has licensed Polypore's intellectual property related to the coating separators.

"This agreement confirms the integrity of our intellectual property around ceramic coating of separators for lithium-ion batteries," said Robert Toth, President and CEO of Polypore. "In addition to the financial consideration of the licensing arrangement, we are pleased that this agreement establishes the opportunity for Polypore and Sumitomo to work together to address growing market needs, which we expect to benefit both companies. As interest in coated separator solutions continues to grow, we believe that the combined strength of our intellectual property, Sumitomo's technical expertise in coating and the exceptional performance characteristics of our separator material create an attractive solution for meeting the growth needs of existing and future customers."

Source: Polypore (http://investor.polypore.net/releasedetail.cfm?ReleaseID=816084), Green Car Congress (http://www.greencarcongress.com/2013/12/20131231-polypore.html), Bloomberg (http://www.bloomberg.com/news/2013-02-25/polypore-s-celgard-files-suit-against-sumitomo-over-batteries.html)

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(https://www.greencarcongress.com/2013/12/20131230-biodiesel.html) EIA: US biodiesel production hits high in October (https://www.greencarcongress.com/2013/12/20131230-biodiesel.html)
ORNL: Speed synchronization through connected vehicle technology contributes to significant fuel economy improvements in conventional and hybrid vehicles (https://www.greencarcongress.com/2013/12/20131231-ornl.html) (https://www.greencarcongress.com/2013/12/20131231-ornl.html)

Polypore and Sumitomo enter settlement and license agreement over battery separator coating (https://www.greencarcongress.com/2013/12/20131231-polypore.html)

31 December 2013 (https://www.greencarcongress.com/2013/12/20131231-polypore.html)

Polypore International, Inc. and Sumitomo Chemical Co., Ltd. have entered (http://investor.polypore.net/releasedetail.cfm?ReleaseID=816084) into a Settlement and License Agreement which ends all outstanding worldwide litigation between the two companies related to Polypore’s intellectual property rights on battery separator coating.

Under the License Agreement, Sumitomo Chemical has licensed Polypore’s intellectual property related to coating separators for lithium-ion batteries. The financial terms of the Agreement include an up-front payment to Polypore as well as recurring royalties.

> *This agreement confirms the integrity of our intellectual property around ceramic coating of separators for lithium-ion batteries. In addition to the financial consideration of the licensing arrangement, we are pleased that this agreement establishes the opportunity for Polypore and Sumitomo to work together to address growing market needs, which we expect to benefit both companies. As interest in coated separator solutions continues to grow, we believe that the combined strength of our intellectual property, Sumitomo's technical expertise in coating and the exceptional performance characteristics of our separator material create an attractive solution for meeting the growth needs of existing and future customers.*
>
> —Robert Toth, President and CEO of Polypore

Polypore International is a high technology filtration company specializing in microporous membranes; it operates two businesses: Energy Storage and Separations Media. Within energy storage fall Celgard, for high-performance lithium-ion battery separators; and Daramic, for battery separators for lead-acid batteries and specialty applications.

Posted on 31 December 2013 in Brief (https://www.greencarcongress.com/brief/) | Permalink (https://www.greencarcongress.com/2013/12/20131231-polypore.html) | Comments (0) (https://www.greencarcongress.com/2013/12/20131231-polypore.html#comments)

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In Brief

FCA selects HARMAN (Samsung) and Google Technologies for New global connected vehicle "ecosystem" (https://www.greencarcongress.com/2019/05/20190501-fca.html)

Cummins reviewing emissions certification and compliance process for its pickup truck applications (https://www.greencarcongress.com/2019/05/20190501-cummins.html)

Agility launches 6x2 44-tonne CNG tractor and trailer-mounted CNG system for UK market (https://www.greencarcongress.com/2019/05/201905021-agility.html)

Toyota selects Novelis as aluminum supplier for 2019 RAV4; Advanz 6HS – s600 and Advanz 6HS – e600 (https://www.greencarcongress.com/2019/05/20190501-toyota.html)

Nouryon signs deal with SulNOx for additives for the fuels market (https://www.greencarcongress.com/2019/05/20190501-nouryon.html)

NuScale and DHIC partner on deploymeny of NuScale SMR (https://www.greencarcongress.com/2019/04/20190430-nuscale.html)

Ballard launches turnkey hydrogen fuel cell solutions for commercial unmanned aerial vehicles (https://www.greencarcongress.com/2019/04/20190429-fcair.html)

Semcon develops cloud solution for autonomous drones (https://www.greencarcongress.com/2019/04/20190429-semcon.html)

New green RoRo vessels for Finnlines designed by KNUD E. HANSEN (https://www.greencarcongress.com/2019/04/20190427-hansen.html)

Continental introduces first tire optimized for electric buses in city traffic (https://www.greencarcongress.com/2019/04/20190426-conti.html)

Zero Motorcycles closes $25M round, bringing aggregate investment to >$250M (https://www.greencarcongress.com/2019/04/20190426-zero.html)

Velodyne Lidar, Nikon announce manufacturing agreement for mass production of Velodyne lidar sensors (https://www.greencarcongress.com/2019/04/20190426-velodyne.html)

Grove Hydrogen partners with Hofer on electric drive solutions (https://www.greencarcongress.com/2019/04/20190425-grove.html)

Penske Truck Leasing to deploy heavy-duty DC fast charging stations in SoCal (https://www.greencarcongress.com/2019/04/20190425-penske.html)

Trillium debuts new recharging product for electric vehicle fleets (https://www.greencarcongress.com/2019/04/20190425-trillium.html)

Austin becomes fifth city in Texas to purchase Proterra battery-electric buses (https://www.greencarcongress.com/2019/04/20190425-proterra.html)

CDFA and CARB launch public-private partnership to advance carbon farming (https://www.greencarcongress.com/2019/04/20190425-arb.html)

EVConnect launches certification program for electric vehicle charging station manufacturers (https://www.greencarcongress.com/2019/04/20190424-evconnect.html)

Sandia releases QuESt v1.2 open-source software for energy storage (https://www.greencarcongress.com/2019/04/20190424-quest.html)

SP VICTALL partners with JMC on first composite pickup box in China; reduced weight and cost (https://www.greencarcongress.com/2019/04/20190424-jmc.html)

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EXHIBIT E

Celgard Files Patent Infringement Lawsuit Against LG Chem, Ltd.

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January 30, 2014 16:15 ET | **Source:** Polypore International, Inc.

CHARLOTTE, N.C., Jan. 30, 2014 (GLOBE NEWSWIRE) -- Celgard, LLC ("Celgard"), a subsidiary of Polypore International, Inc. (NYSE:PPO), announced today that it has filed a complaint in the U.S. District Court of the Western District of North Carolina against LG Chem, Ltd. and LG Chem America, Inc. (collectively "LG").

The complaint alleges that LG has infringed Celgard's United States Patent No. 6,432,586 issued for an invention entitled "Separator for a High Energy Rechargeable Lithium Battery." The patent in the lawsuit covers ceramic composite layer lithium-ion battery separators first developed by Celgard for high-energy rechargeable lithium-ion batteries. This lawsuit has been filed following a lengthy period of unsuccessful discussions with LG regarding various business terms of its relationship with Celgard, including infringement of Celgard's patent. Celgard is represented by the law firm Kilpatrick Townsend & Stockton, LLP.

"Celgard has a long history of innovation in lithium-ion battery separators and is a proven world leader in this technology. We value long-term customer relationships, and we are interested in partnerships that reflect the value of our products in applications such as electric drive vehicles ("EDVs"), where exceptional safety and performance characteristics are critical," said Robert B. Toth, President and Chief Executive Officer of Polypore. "We supported LG for years under a formalized memorandum of understanding that was intended to result in a long-term supply agreement, investing substantial capital at their request and developing and qualifying high quality products with unique attributes. Unfortunately, after a long period of support and discussions, LG's recent approach and demands were simply unacceptable.

"Legal action is not a decision we take lightly. However, LG's recent approach in both consumer electronics and EDV applications leaves us with no choice," added Toth. "While LG has not confirmed this in writing to us as we requested, representatives of LG have verbally stated that they are attempting to qualify alternate sources of supply to Celgard separator—an action we believe constitutes further infringement of our coating patents. We are taking this action on behalf of our company and our shareholders to safeguard our assets, and we will continue to take appropriate steps to protect our intellectual property."

During the fourth quarter of 2013, Polypore recorded no revenues from LG and expects to report fourth quarter sales for the Electronics and EDVs segment to be in the low- to mid-$30 million range.

Polypore expects to announce its fourth quarter and full year 2013 financial results on February 24, 2014 after market close and will take questions regarding current business matters at that time.

About Polypore International, Inc.

Polypore International, Inc. is a global high technology filtration company specializing in microporous membranes. Polypore's flat sheet and hollow fiber membranes are used in specialized applications that require the removal or separation of various materials from liquids, primarily in the ultrafiltration and microfiltration markets. Based in Charlotte, NC, Polypore International, Inc. is a market leader with manufacturing facilities or sales offices in nine countries serving six continents. See **www.polypore.net**.

Forward-Looking Statements

This release contains statements that are forward-looking in nature. Statements that are predictive in nature, that depend upon or refer to future events or conditions or that include words such as "expects," "anticipates," "intends," "plans," "believes," "estimates," and similar expressions are forward-looking statements. These statements involve known and unknown risks, uncertainties and other factors that may cause our actual results and performance to be materially different from any future results or performance expressed or implied by these forward-looking statements. These factors include the following: the highly competitive nature of the markets in which we sell our products; the failure to continue to develop innovative products; the loss of our customers; the vertical integration by our customers of the production of our products into their own manufacturing process; increases in prices for raw materials or the loss of key supplier contracts; our substantial indebtedness; interest rate risk related to our variable rate

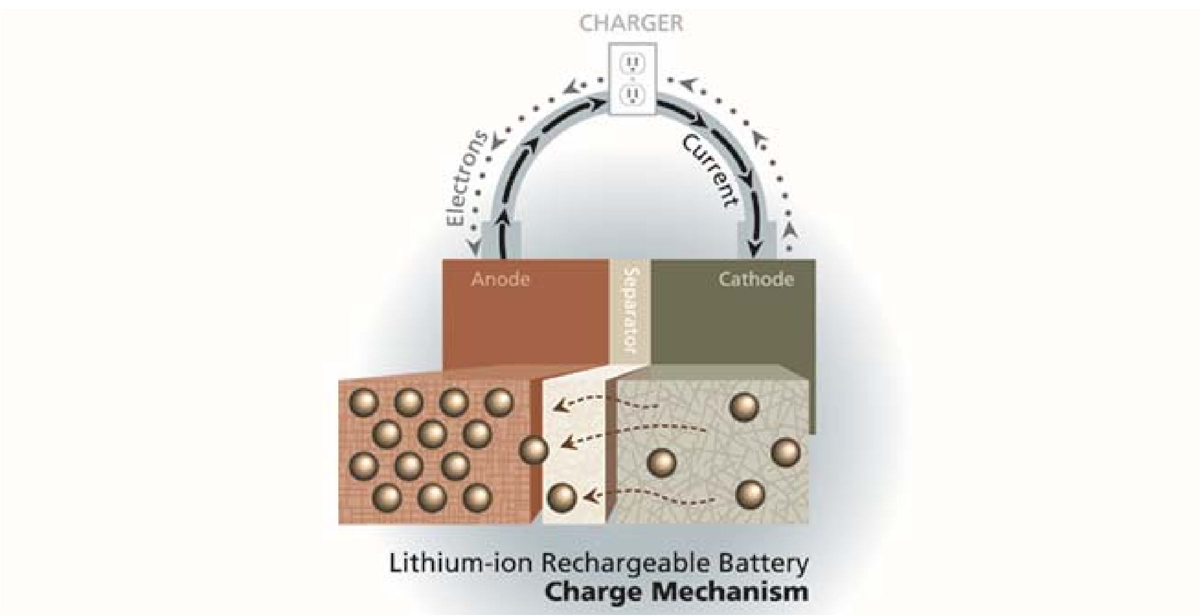
indebtedness; our inability to generate cash; restrictions related to the senior secured credit agreement; employee slowdowns, strikes or similar actions; product liability claims exposure; risks in connection with our operations outside the United States, including compliance with applicable anti-corruption laws; the incurrence of substantial costs to comply with, or as a result of violations of, or liabilities under, environmental laws; the failure to protect our intellectual property; the loss of senior management; the incurrence of additional debt, contingent liabilities and expenses in connection with future acquisitions; the failure to effectively integrate newly acquired operations; lithium market demand not materializing as anticipated; the absence of expected returns from the intangible assets we have recorded; and natural disasters, epidemics, terrorist acts and other events beyond our control. Additional information concerning these and other important factors can be found in Item 1A. "Risk Factors" of our most recent Annual Report on Form 10-K and subsequent reports filed with the Securities and Exchange Commission. Such forward-looking statements speak only as of the date of this press release. Polypore expressly disclaims any obligation to release publicly any updates or revisions to any forward-looking statements contained herein to reflect any change in Polypore's expectations with regard thereto or change in events, conditions or circumstances on which any statement is based.

Polypore International, Inc.

Investor Relations
Paul Clegg
(704) 587-8886

Celgard files suit against LG Chem over battery separator patent

Posted February 4, 2014 by Charles Morris (https://chargedevs.com/author/charles-morris/) & filed under Newswire (https://chargedevs.com/category/newswire/), The Tech (https://chargedevs.com/category/newswire/the-tech/).



Celgard, a subsidiary of Polypore International (NYSE:PPO), has filed a complaint against LG Chem, alleging that the Korean chemical giant has infringed one of Celgard's US patents for a battery separator.

The patent in question covers ceramic composite layer lithium-ion battery separators. Celgard filed the lawsuit following a lengthy period of discussions with LG regarding the two companies' business relationship.

Battery separators, which keep anode and cathode apart (it would not be a happy meeting), are much in the news lately (http://chargedevs.com/newswire/polypore-and-sumitomo-sign-license-agreement-for-battery-separator-coating/). As demand for lithium-ion batteries grows, the companies that make these critical components are embroiled in a web of intrigue. LG Chem recently lost a lawsuit (http://chargedevs.com/newswire/sk-innovation-wins-battery-separator-patent-lawsuit/) with another Korean company, SK Innovation, which also involved battery separator patents.

"Celgard supported LG for years under a formalized memorandum of understanding that was intended to result in a long-term supply agreement, investing substantial capital at their request and developing and qualifying high-quality products with unique attributes," said Polypore CEO Robert B. Toth. "Unfortunately, after a long period of support and discussions, LG's recent approach and demands were simply unacceptable…representatives of LG have verbally stated that they are attempting to qualify alternate sources of supply to Celgard – an action we believe constitutes further infringement of our coating patents."

Separately, Polypore announced this week that Celgard has entered into a long-term agreement to supply separators to Samsung SDI.

Source: Polypore (http://investor.polypore.net/releasedetail.cfm?releaseid=822260) via Green Car Congress (http://www.greencarcongress.com/2014/01/20140131-celgard1.html)Image courtesy of Celgard

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Celgard files patent infringement lawsuit against LG Chem over Li-ion separator technology (https://www.greencarcongress.com/2014/01/20140131-celgard1.html)

31 January 2014 (https://www.greencarcongress.com/2014/01/20140131-celgard1.html)

Celgard, LLC, a subsidiary of Polypore International, Inc., filed (http://investor.polypore.net/releasedetail.cfm?releaseid=822260) a complaint in the US District Court of the Western District of North Carolina against LG Chem, Ltd. and LG Chem America, Inc.. The complaint alleges that LG has infringed Celgard’s United States Patent Nº 6,432,586 issued for an invention entitled “Separator for a High Energy Rechargeable Lithium Battery.”

The patent in the lawsuit covers ceramic composite layer lithium-ion battery separators developed by Celgard for high-energy rechargeable lithium-ion batteries. This lawsuit has been filed following a lengthy period of unsuccessful discussions with LG regarding various business terms of its relationship with Celgard, including infringement of Celgard’s patent. Celgard is represented by the law firm Kilpatrick Townsend & Stockton, LLP.

Celgard battery separators are polypropylene (PP), polyethylene (PE), or trilayer PP/PE/PP electrolytic separator membranes.

Earlier in January, LG announced that it obtained a patent for its safety-reinforced separator (SRS) in Europe and Japan. LG Chem now has SRS patents in five regions, including South Korea, the United States and China. SRS uses nanoscale ceramic particles to prevent internal short circuits. LG Chem is also embroiled in litigation with another S. Korean company, SK Innovation, over the separator technology. (Earlier post (http://www.greencarcongress.com/2014/01/20140122-lgchem.html).)

Separately, Polypore announced that Celgard and Samsung SDI Co., Ltd. have entered (http://investor.polypore.net/releasedetail.cfm?releaseid=822261) into a long-term supply agreement under which Samsung will purchase Celgard brand separator to be used in its electric drive vehicle and energy storage system lithium-ion batteries. (Earlier post (http://www.greencarcongress.com/2014/01/20140131-celgard2.html).)

> *Celgard has a long history of innovation in lithium-ion battery separators and is a proven world leader in this technology. We value long-term customer relationships, and we are interested in partnerships that reflect the value of our products in applications such as electric drive vehicles (EDVs), where exceptional safety and performance characteristics are critical.*

> *We supported LG for years under a formalized memorandum of understanding that was intended to result in a long-term supply agreement, investing substantial capital at their request and developing and qualifying high quality products with unique attributes. Unfortunately, after a long period of support and discussions, LG's recent approach and demands were simply unacceptable.*

> *Legal action is not a decision we take lightly. However, LG's recent approach in both consumer electronics and EDV applications leaves us with no choice. While LG has not confirmed this in writing to us as we requested, representatives of LG have verbally stated that they are attempting to qualify alternate sources of supply to Celgard separator—an action we believe constitutes further infringement of our coating patents. We are taking this action on behalf of our company and our shareholders to safeguard our assets, and we will continue to take appropriate steps to protect our intellectual property.*
>
> —Robert B. Toth, President and CEO of Polypore

During the fourth quarter of 2013, Polypore recorded no revenues from LG and expects to report fourth quarter sales for the Electronics and EDVs segment to be in the low- to mid-$30 million range.

Posted on 31 January 2014 in Brief (https://www.greencarcongress.com/brief/) | Permalink (https://www.greencarcongress.com/2014/01/20140131-celgard1.html) | Comments (1) (https://www.greencarcongress.com/2014/01/20140131-celgard1.html#comments)

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So many people are trying to get $$$M from Samsung with doubtful claims. This may be another one of them.

Unfortunately, all those legal claims can slow the arrival of improved batteries and benefit Oilcos and ICEVs manufacturers.

Posted by: HarveyD (https://profile.typepad.com/harveyd) | 31 January 2014 at 10:11 AM (https://www.greencarcongress.com/2014/01/20140131-celgard1.html?cid=6a00d8341c4fbe53ef01a51160627c970c#comment-6a00d8341c4fbe53ef01a51160627c970c)

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EXHIBIT F

SK Innovation to expand production of lithium-ion battery separators

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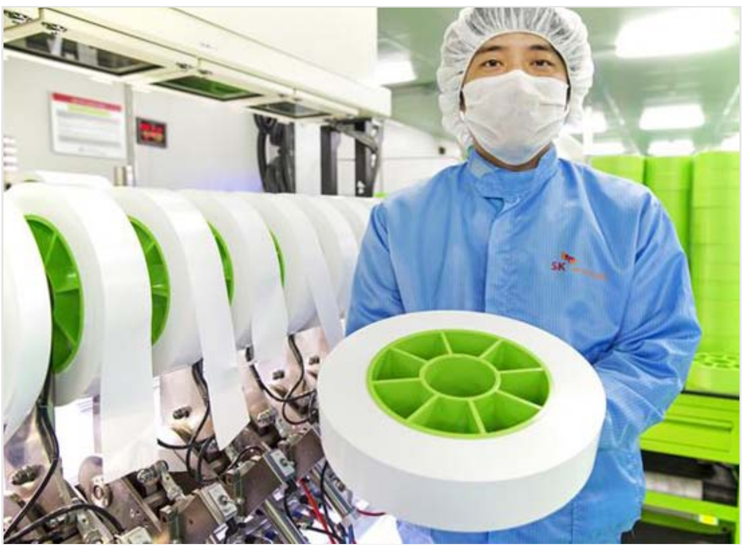

SK Innovation Co., the energy solutions arm of South Korean conglomerate SK Group, said on Thursday that it has decided to expand its manufacturing facility in Jeungpyeong, North Chungcheong, to ramp up output of lithium-ion battery separators (LiBS), a core component in developing electric vehicles. Ground-breaking is set for May.

LiBS is a technological component that separates negative and positive electrodes in smartphone and electric vehicle batteries that help prevent possible explosion or ignition. SK Innovation was the first in the country and third in the world to develop its own commercial-use battery separators in 2004. The nine production lines at the company's facility in Jeungpyeong is responsible for 17 percent of global LiBS demand.

According to SK Innovation, once it completes the construction of expanding its manufacturing facility in the first half of 2018, the company will be capable of producing 330 million square meters of LiBS per year. The volume is enough to be fit and support 1 million all-electric vehicles.

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An unnamed official from SK Innovation said that demand for battery separators has been on a rise in sync with rapid growth in the world's electric vehicle and smartphone market. The company will become the world's second-largest LiBS producer after expansion and reach closer to its goal of becoming the world's largest by 2020.

The decision to expand its production facility is known to have picked up speed after SK Innovation ended the three-year court battle with Celgard - now Asahi Kasei - a Japanese producer of battery separators, over patent rights last month. The dispute first began in 2013 when the Japanese company filed a lawsuit against SK Innovation claiming that it was using its patented technologies with regard to LiBS.

SK Innovation sold 1 trillion won ($875 million) of battery separators so far since it began commercial production in 2005. Another SK Innovation official said that one in every five laptops and mobile phones in the world uses batteries that are fitted with SK Innovation's LiBS.

Meanwhile, SK Innovation has also been aggressive in expanding its presence in the electric vehicle battery business, based on the LiBS technology. In July, last year, the company increased the annual production capacity of its battery plant in Seosan, North Chungcheong, from 15,000 units to 30,000 units per year. In March - only after 8 months - the company announced additional expansion in the production by 10,000 units.

By Chung Wook

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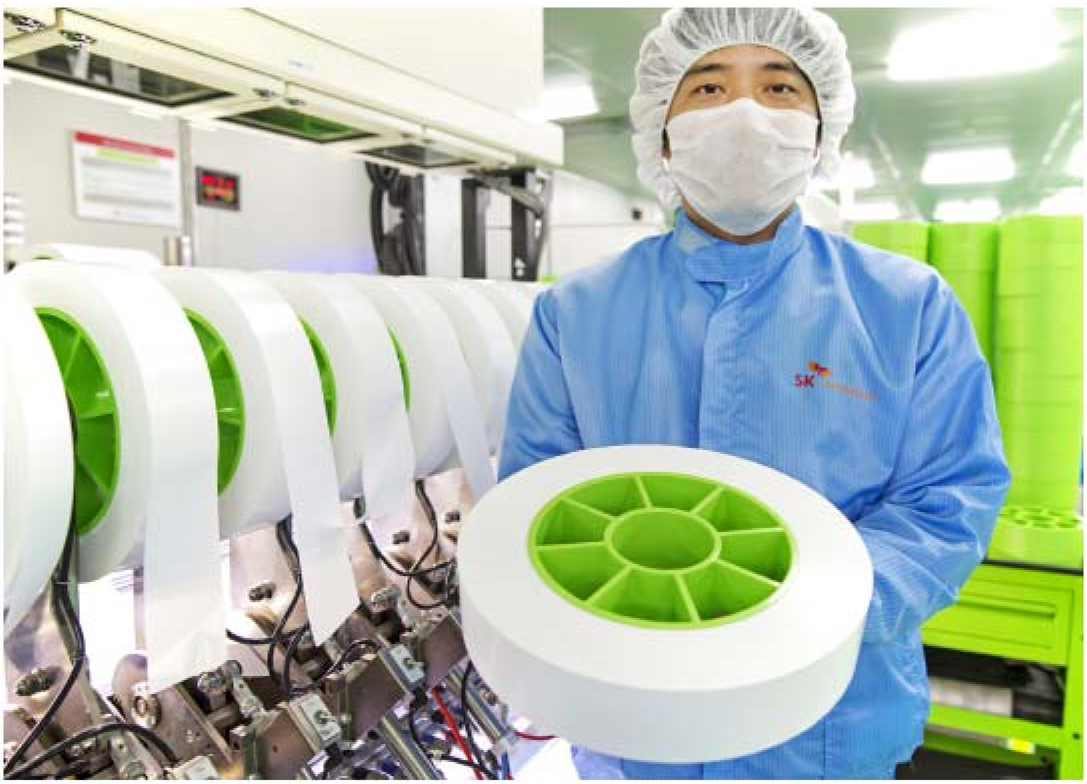
Lithium-ion Battery Separator

SK Innovation to Seek to Win Largest Share in Global EV Battery Membrane Market

By Jung Min-hee | 2016.04.29 01:15



An employee at SK Innovation's plant in Jeungpyeong, North Chungcheong Province, holds a lithium-ion battery separator (LiBS), a core component for EV batteries.

SK Innovation Co., the energy solutions arm of SK Group, will seek to increase the production of lithium-ion battery separator (LiBS), a core component for electric vehicle (EV) batteries, by 30 percent and win the largest share in the global market by 2020.

The company announced on Apr. 28 that it will start the construction to expand two LiBS production lines (unit 10 and 11) at the Jeungpyeong plant in North Chungcheong Province from next month.

LiBS is a technological component that separates negative and positive electrodes in smartphone and EV batteries that help prevent possible explosion or ignition. It is a micrometer-thin film divided into dry or wet according to the manufacturing methods. SK Innovation produces wet LiBS, which takes more money to produce but has excellence in quality and strength.

Once the company completes the construction of expanding its manufacturing facility in the first half of 2018, it will be capable of producing 330 million square meters of LiBS per year. The volume is enough to be fit and support 1 million all-electric vehicles.

SK Innovation, the world's second-largest LiBS producer with a 26 percent share in the wet LiBS market as of 2015, plans to become the world's largest after expansion by 2020, surpassing Japan's Asahi Kasei.

The company ended the three-year court battle with Celgard, the current Asahi Kasei, over separator patent rights by mutual consent last month, removing uncertainties.

SK Innovation was the first in the country and third in the world to develop its own commercial-use battery separators in 2004, and begin the first commercial production at the first line in the Cheongju plant, North Chungcheong Province, in Jan. 20015. The company accomplished surplus in two years after the commercial production and increased the number of its production lines to nine in 2014.

SK Innovation plans to diversify its business portfolio by strengthening new businesses, like EV battery, in addition to existing refining and petrochemical businesses in a bid to establish a business structure that make a profit despite the economic recession.

Jung Min-hee

EXHIBIT G

Celgard Files Lawsuit Against MTI Corporation for Patent Infringement of Ceramic Coated Separators Used in Lithium Batteries

English ▾

POLYPORE

NEWS PROVIDED BY
Polypore International, LP →
Dec 13, 2018, 18:15 ET

CHARLOTTE, N.C., Dec. 13, 2018 /PRNewswire/ -- Celgard, LLC ("Celgard"), a subsidiary of Polypore International, LP, filed a complaint in U.S. District Court for the Northern District of California against MTI Corporation ("MTI"), seller of ceramic coated separators for lithium batteries in Richmond, California, USA.

The complaint alleges that MTI has infringed Celgard's United States Patent No. 6,432,586 issued for an invention entitled "Separator for a High Energy Rechargeable Lithium Battery." The patent in the lawsuit covers ceramic composite layer lithium-ion battery separators first developed by Celgard for high-energy rechargeable lithium-ion batteries. The lawsuit seeks an injunction preventing MTI from selling ceramic coated battery separators that infringe Celgard's patent and it also seeks compensation for damages.

A separate complaint filed by Celgard in U.S. District Court for the Western District of North Carolina against MTI seeks an injunction preventing MTI from infringing trademarks and from selling unauthorized and counterfeit ceramic coated battery separators with the Celgard® registered brand name and Celgard® labeling, and also seeks compensation for damages.

Celgard is taking these actions to safeguard its assets and customers, and will continue to take appropriate steps to prevent the unfair exploitation of its intellectual property.

About Celgard, LLC

Celgard, LLC specializes in developing, manufacturing and marketing coated and uncoated dry-process microporous membranes used as separators in various lithium-ion batteries that play a critical role in the performance, life and safety of lithium battery cells. Celgard's battery separator technology is used in lithium batteries for electric drive vehicles, energy storage systems and other specialty applications.

Celgard is a wholly-owned subsidiary of Polypore International, LP. For more information, visit www.celgard.com

About Polypore International, LP

Polypore International, LP, an Asahi Kasei Group company, specializes in highly-engineered microporous membranes used in electric drive vehicles, energy storage systems and emergency backup power systems, portable consumer electronic devices, cars, trucks, buses, and forklifts. A global high-technology company based in Charlotte, North Carolina, Polypore International, LP is highly regarded in the market with manufacturing facilities or sales offices in nine countries serving six continents. For more information, visit www.polypore.com.

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Celgard, LLC, a subsidiary of Polypore International, LP, filed (https://prnmedia.prnewswire.com/news-releases/celgard-files-lawsuit-against-mti-corporation-for-patent-infringement-of-ceramic-coated-separators-used-in-lithium-batteries-300765517.html?c=n) a complaint in U.S. District Court for the Northern District of California against MTI Corporation, seller of ceramic coated separators for lithium batteries in Richmond, California.

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- Synthetic Biology (https://www.greencarcongress.com/synthetic_biology/)
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EXHIBIT H

Celgard Successfully Sues Targray on Infringement of Celgard's Ceramic Coated Battery Separator Patent

English

NEWS PROVIDED BY
Polypore International, LP →
Sep 12, 2019, 09:00 ET

CHARLOTTE, N.C., Sept. 12, 2019 /PRNewswire/ -- Celgard, LLC (Celgard), a subsidiary of Polypore International, LP, was successful in its patent litigation in California against Targray International of Canada (Targray) on infringement of Celgard's ceramic coated battery separator patent (U.S. Patent 6,432,586, now U.S. Patent RE47,520) and Celgard's polypropylene separator patent (U.S. Patent 6,692,867). Celgard and Targray have settled all outstanding litigation between the two companies related to Targray's infringements.

Celgard® microporous coated and uncoated membranes used as separators in various lithium-ion batteries.

Targray agreed to stop selling, distributing or importing all allegedly infringing battery separators, such as those manufactured by Shenzhen Senior Technology Material Co., Ltd. ("Senior"), Senior International (HK) Co., Limited, W-Scope Corporation and Gelon LIB Co., Limited. Targray agreed they would not make, use, offer to sell, sell, distribute, or import any separators globally covered by Celgard's existing patents.

In the case, Targray did not contest the infringement, validity or enforceability of Celgard's patents. Targray also agreed to not challenge the validity of Celgard's '586 (now '520) and '867 Patents.

The successful outcome of the Targray case further solidifies the integrity of Celgard's intellectual property (IP) regarding coated and uncoated separators for lithium-ion batteries.

Earlier, Celgard successfully settled two suits against MTI Corporation of California (MTI). The first was a patent suit in California under the same '586 Patent seeking relief from MTI for selling infringing ceramic coated battery separators manufactured by Foshan Jinhui Hi-Tech Optoelectronic Material Co., Ltd. in China. The second was a trademark suit in North Carolina seeking relief from MTI for selling unauthorized and counterfeit battery separators. MTI and several related MTI companies agreed to stop selling all coated and uncoated battery separators.

Celgard will continue to take appropriate steps to prevent the unfair exploitation of its technology and IP to safeguard its assets and customers.

About Celgard, LLC and Polypore International, LP

Celgard specializes in developing and manufacturing coated and uncoated dry-process microporous membranes used as separators that are a major component of lithium-ion batteries. Celgard's battery separator technology is important to the performance of lithium batteries for electric drive vehicles, energy storage systems and other specialty applications.

Celgard is a wholly-owned subsidiary of Polypore International, LP, an Asahi Kasei Company.

Polypore is a global company with facilities in nine countries serving six continents specializing in highly-engineered microporous membranes used in electric drive vehicles, energy storage systems, cars, trucks, buses, and forklifts. Visit www.celgard.com and www.polypore.com.

SOURCE Polypore International, LP

Related Links

http://www.polypore.com

EXHIBIT I

TARGRAY

Ceramic Separators

Fully Ceramic Separators for Lithium-ion Battery Manufacturing & Research

An Exceptional Combination of Safety & Performance

The latest addition to Targray's line of battery separators, our ceramic separators delivers an exceptional combination of safety, temperature performance and life cycle for lithium-ion battery manufacturers and R&D facilities. Given their rigorous safety and performance features, our ceramic separators are ideally suited for advanced li-ion battery applications, namely electric vehicles and energy storage systems.

Ceramic Separators: Key Features & Benefits

- Proven to be highly suitable for high-power (*150 C*) and high temperature (*over 100° C*) battery applications.
- Fully compatible with a range of processing technologies including stacking, winding and z-folding.
- Features superior wettability, which allows for the faster & more uniform absorption of electrolyte.
- Demonstrates great resistance in typical abuse scenarios. *(Nail penetration test)*
- Minimal shrinkage – less than 1% of shrinkage occurs after 24 hours at 200°C.
- Enables the fast & thorough drying of stacks / jelly rolls at 130°C and above.

- Ultra-long life cycle & calendar life. (*up to 9000 cycles at 100% DoD*)
- Retains mechanical integrity in high heat, up to 240°C.
- Qualified for use in automotive industry applications.

Working closely with our supply partners and organizations including the Electrochemical Society and NAATBatt International, we help lithium-ion battery manufacturers and researchers worldwide commercialize ambitious new technologies for the energy storage market. Contact us today to learn more.

Related Products

PVDF & SBR Binders

Our Lithium-ion battery raw materials portfolio includes Aqueous and PVDF Anode Binders.

Anode Foil Material

Targray offers Copper and Nickel Foils depending on the application of the Lithium-ion battery.

Cathode Materials

Targray supplies a complete catalog of Cathode Materials for use by Li-ion battery manufacturers.

+1 (514) 695-8095

To speak with a Targray representative.

Sign Up for Li-ion Battery Industry Alerts

Sign up to the Targray Li-ion Battery Newsletter for all the latest **lithium-ion battery** industry news and insights. Subscribers are also among the first to receive battery division product alerts and special announcements.

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Solar PV Solutions

- Solar Financing
- Inventory Management
- Solar Silicon Materials
- Solar PV Modules
- Solar PV Cells
- Solar Wafers

Battery Materials

- Electrolyte Solutions
- Separator Materials
- Battery Electrodes
- Battery Packaging
- Cathode Materials
- Graphite Materials

Biodiesel Solutions

- Wholesale Biodiesel
- Biodiesel Marketing
- EU Biodiesel Trading
- U.S. Distribution Network
- International Exports
- Blending Guide

Corporate Information

- Business Divisions
- Company History
- Company Awards

- Industry Partners
- Job Openings
- Latest News

Privacy - Terms

EXHIBIT J

Battery Division

Advanced Battery Materials

High-performance Separators

Polyethylene and polypropylene separator materials for battery manufacturing

One of the most important components to ensure li-ion cell safety is the separator, a thin porous membrane that physically separates the anode and cathode. The separator is used to prevent physical contact between the anode and cathode, while facilitating ion transportation in the cell. Consequently, an effective battery separator should provide excellent mechanical strength without sacrificing porosity.

Targray polypropylene- and polyethylene battery-grade separator rolls contain micro- and nano pores to provide excellent ion transportation within the cell. Characterized by a highly uniform thickness and excellent puncture resistance, our separators are available in a ceramic-coated variant that offers enhanced thermal deformation resistance and mechanical robustness.

TARGRAY

High-performance Separators

High elongation Separator (ST)

Offering best-in-class impact resistance, our new ST separators are designed to extend upon harsh impact to resist breakage. Characterized by a small pore size, uniform distribution, and a high puncture and DB strength, our ST separator materials are ideal for NCM- and NCA-based battery chemistries.

Product number		ST212D	ST214C	ST216D	ST216E	ST420C
Thickness		12.0±2.0μm	14.0±2.0μm	16.0±2.0μm	16.0±2.0μm	20.0±2.0μm
Gurley (s/100ml)		170±60	230±70	220±60	170±60	330±80
Porosity (%)		43.0±3.0	39.0±3.0	43.0±3.0	47.0±3.0	38.0±3.0
Base weight (g/m^2)		6.3±1.0	7.9±1.0	8.4±1.0	7.7±1.0	11.5±1.0
Puncture strength (g)		≥220	≥250	≥280	≥280	≥400
Tensile strength (kgf/cm^2)	MD	≥1600	≥1600	≥1600	≥1600	≥1600
	TD	≥140	≥140	≥140	≥140	≥140
Thermal shrinkage (% 120℃*1h)	MD	≤5.0	≤5.0	≤5.0	≤5.0	≤3.0
	TD	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5

TARGRAY

High-performance Separators

Wrinkle-resistant Separator (SZ)

Our new SZ separators were developed specifically to address wrinkling issues occurring during electrolyte injection.

Product number		SZ212202	SZ214202	SZ216102	SZ216202	SZ218202
Thickness		12.0±2.0	14.0±2.0	16.0±2.0	16.0±2.0	18.0±2.0
Gurley (s/100ml)		170±50	210±50	290±70	230±70	260±70
Porosity (%)		42.0±3.0	39.0±3.0	37.0±3.0	40.0±3.0	40.0±3.0
Base weight (g/m^2)		6.3±1.0	8.1±1.0	9.0±1.0	8.7±1.0	9.8±1.0
Puncture strength (g)		≥200	≥220	≥280	≥280	≥320
Tensile strength (kgf/cm^2)	MD	≥1500	≥1500	≥1500	≥1500	≥1500
	TD	≥130	≥130	≥130	≥130	≥130
Thermal shrinkage (% 120℃*1h)	MD	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0
	TD	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5

TARGRAY

High-performance Separators

Wet Process Polyethylene Separators (SW)

Designed using polyethylene with an ultra-high molecular weight, our SW separators are produced via a wet stretch process that yields excellent thickness, uniformity, and tensile strength. Polyethylene separators are widely used in batteries for consumer electronics, as well as well as in large format lithium-ion cells.

Product number		SW312D	SW312F	SW316E	SW320H	SW517E
Porosity (%)		40±3	44±5	42±3	48±3	42±3
Thickness (μm)		12±1.5	12±2	16±2	20±2	17±2
Density (g/m^2)		6.9±1.0	6.4±1.0	8.9±1.0	10.0±1.0	9.5±1.0
Permeability (S/100ml)		200±50	≤170	200±50	180±50	200±50
Puncture strength (g)		≥400	≥400	≥530	≥600	≥580
Tensile strength (kgf/cm^2)	MD	≥1700	≥1700	≥1600	≥1600	≥1600
	TD	≥1400	≥1400	≥1400	≥1400	≥1400
Shrinkage (%,90℃ 2h)	MD	≤2.5	≤2.5	≤2.5	≤2.5	≤2.5
	TD	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Shrinkage (%,105℃ 1h)	MD	≤4.0	≤4.5	≤4.0	≤4.0	≤4.0
	TD	≤1.5	≤2.5	≤1.5	≤1.5	≤1.5

TARGRAY

High-performance Separators

Wet Process Polyethylene Separators (SW)

Designed using polyethylene with an ultra-high molecular weight, our SW separators are produced via a wet stretch process that yields excellent thickness, uniformity, and tensile strength. Polyethylene separators are widely used in batteries for consumer electronics, as well as well as in large format lithium-ion cells.

Product number		SW312D	SW312F	SW316E	SW320H	SW517E
Porosity (%)		40±3	44±5	42±3	48±3	42±3
Thickness (μm)		12±1.5	12±2	16±2	20±2	17±2
Density (g/m^2)		6.9±1.0	6.4±1.0	8.9±1.0	10.0±1.0	9.5±1.0
Permeability (S/100ml)		200±50	≤170	200±50	180±50	200±50
Puncture strength (g)		≥400	≥400	≥530	≥600	≥580
Tensile strength (kgf/cm^2)	MD	≥1700	≥1700	≥1600	≥1600	≥1600
	TD	≥1400	≥1400	≥1400	≥1400	≥1400
Shrinkage (%,90℃ 2h)	MD	≤2.5	≤2.5	≤2.5	≤2.5	≤2.5
	TD	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Shrinkage (%,105℃ 1h)	MD	≤4.0	≤4.5	≤4.0	≤4.0	≤4.0
	TD	≤1.5	≤2.5	≤1.5	≤1.5	≤1.5

TARGRAY

High-performance Separators

Ceramic-coated Wet Process Polyethylene Separators (SW)

Our SW separators are also available with aluminum oxide ceramic coating to further enhance safety characteristics.

Base product number		SW312D		SW312F		SW316E		SW320H	
Product number		SH416W14	SH416W22	SH716W14	SH716W22	SH220W14	SH220W22	SH624W14	SH624W22
Coating method		single side	double side	single side	double side	single side	double side	single side	double side
Porosity (%)		40±5	40±5	44±5	44±5	42±5	42±5	48±5	48±5
Thickness (μm)		16±2	16±2	16±2	16±2	20±2	20±2	24±2	24±2
Density (g/m^2)		14±3.0	14±3.5	13.5±3.0	13.5±3.0	16±3	16±3	17±3.0	17±3.5
Permeability (S/100ml)		230±70	250±70	170±70	190±70	240±70	260±70	220±70	240±70
Puncture strength (g)		≥400	≥400	≥350	≥350	≥480	≥480	≥550	≥550
Tensile strength (kgf/cm^2)	MD	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1200	≥1200
	TD	≥950	≥950	≥950	≥950	≥1000	≥1000	≥1000	≥1000
Shrinkage (%,90℃ 2h)	MD	≤2.5	≤2.5	≤2.5	≤2.5	≤2.5	≤2.5	≤2.5	≤2.5
	TD	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5
Shrinkage (%,105℃ 1h)	MD	≤4	≤4.5	≤4	≤4.5	≤4	≤4.5	≤4	≤4.5
	TD	≤4	≤4.5	≤4	≤4.5	≤4	≤4.5	≤4	≤4.5

High-performance Separators

Standard Dry Process Polypropylene Separators (SD)

Available in a wide range of thicknesses, our advanced polypropylene separator materials are characterized by a high shut down temperature and excellent mechanical strength, which makes them suitable for use in EV batteries and other power cell applications.

Thickness		16µm			20µm			25µm			32µm			40µm		60µm
Product number		SD216001	SD216101	SD216201	SD220001	SD220101	SD220201	SD425201	SD425301	SD425401	SD432101	SD432201	SD432301	SD440201	SD440301	SD460201
Thickness (µm)		±2	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2	±2
Permeability (s/100ml)		450±120	320±100	250±80	550±150	450±120	320±100	380±100	300±80	200±50	560±150	500±150	400±150	600±150	480±150	900±200
Porosity (%)		33±3	37±3	42±3	33±3	37±3	42±3	42±3	47±3	53±3	37±3	42±3	47±3	42±3	47±3	42±3
Density (g/m^2)		10.0±1.0	9.1±1.0	8.5±1.0	12.2±1.0	11.5±1.0	10.5±1.0	13.2±1.0	12.1±1.0	10.0±1.0	18.4±1.5	16.8±1.5	15.5±1.5	21.1±1.5	19.3±1.5	31.5±2.0
Puncture strength (g)		≥250	≥250	≥220	≥300	≥300	≥280	≥400	≥300	≥300	≥500	≥500	≥480	≥600	≥550	≥800
Tensile strength (kgf/cm^2)	MD	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100	≥1100
	TD	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130	≥130
Shrinkage (%, 90℃ 2h)	MD	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤2.0	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5
	TD	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5
Shrinkage (%, 105℃ 1h)	MD	≤3.5	≤3.5	≤3.5	≤3.5	≤3.5	≤3.5	≤3.5	≤3.5	≤4.0	≤3.5	≤3.5	≤3.5	≤3.5	≤3.5	≤3.5
	TD	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5

TARGRAY

High-performance Separators

High-strength Dry Process Polypropylene Separators (SD)

Targray dry process polypropylene separators are offered in a high-strength variant in sizes ranging from 12 to 25 microns.

Thickness		12µm	14µm	16µm		20µm		25µm
Product number		SD212202	SD214202	SD216102	SD216202	SD220102	SD220202	SD425202
Thickness (µm)		12±2	14±2	16±2	16±2	20±2	20±2	25±2
Permeability (s/100ml)		180±80	220±50	320±100	250±100	450±100	320±100	380±100
Porosity (%)		40±5	40±5	37±3	42±3	37±3	42±3	42±3
Density (g/m^2)		6.8±1.0	7.4±1.0	9.1±1.0	8.5±1.0	11.5±1.0	10.5±1.0	13.2±1.0
Puncture strength (g)		≥180	≥260	≥300	≥300	≥350	≥350	≥450
Tensile strength （kgf/cm^2）	MD	≥1500	≥1500	≥1400	≥1400	≥1400	≥1400	≥1400
	TD	≥120	≥140	≥130	≥130	≥130	≥130	≥130
Shrinkage (%, 90℃ 2h)	MD	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5	≤1.5
	TD	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5
Shrinkage (%, 105℃ 1h)	MD	≤4	≤3	≤3.5	≤3.5	≤3.5	≤3.5	≤3.5
	TD	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5	≤0.5

TARGRAY

High-performance Separators

Ceramic-coated Dry Process Ceramic Separators (SH) | *16μm*

Our dry process polypropylene separators are also available with aluminum oxide ceramic coating to further enhance safety characteristics.

Thickness		16μm					
Product number		SH216D14	SH216D22	SH816D14	SH816D22	SH216Z14	SH216Z22
Coating method		single side	double side	single side	double side	single side	double side
Porosity (%)		42±3	42±3	50±3	50±3	42±3	42±3
Thickness (μm)		16±2	16±2	16±2	16±2	16±2	16±2
Density (g/m^2)		13.4±3.0	13.4±3.5	12.1±3	12.1±3	13.4±3.0	13.4±3.5
Permeability (S/100ml)		220±70	220±70	140±70	150±70	200±70	210±70
Puncture strength (g)		≥140	≥140	≥190	≥190	≥160	≥160
Tensile strength (kgf/cm^2)	MD	≥850	≥850	≥900	≥900	≥950	≥950
	TD	≥95	≥95	≥65	≥65	≥90	≥90
Shrinkage (%,90℃ 2h)	MD	≤2	≤2	≤2	≤2	≤2	≤2
	TD	≤1	≤1	≤0.5	≤0.5	≤1	≤1
Shrinkage (%,105℃ 1h)	MD	≤4	≤4	≤3.5	≤3.5	≤4	≤4
	TD	≤1	≤1	≤0.5	≤0.5	≤1	≤1

TARGRAY

High-performance Separators

Ceramic-coated Dry Process Ceramic Separators (SH) | *20μm*

Our dry process polypropylene separators are also available with aluminum oxide ceramic coating to further enhance safety characteristics.

Thickness		20μm				
Product number		SH220D14	SH220D22	SH620D14	SH620T14	SH320Z14
Coating method		single side	double side	single side	single side	single side
Porosity (%)		42±3	42±3	47±3	47±3	37±3
Thickness (μm)		20±2	20±2	20±2	20±2	20±2
Density (g/m^2)		15.1±3.0	15.1±3.5	14.6±3	14.7±3	16.1±3
Permeability (S/100ml)		270±70	270±70	190±70	200±80	320±100
Puncture strength (g)		≥180	≥180	≥160	≥220	≥220
Tensile strength (kgf/cm^2)	MD	≥850	≥850	≥850	≥1100	≥1000
	TD	≥95	≥95	≥80	≥95	≥100
Shrinkage (%,90℃ 2h)	MD	≤2	≤2	≤2	≤2	≤2
	TD	≤1	≤1	≤1	≤1	≤1
Shrinkage (%,105℃ 1h)	MD	≤4	≤4	≤4	≤4	≤4
	TD	≤1	≤1	≤1	≤1	≤1

TARGRAY

High-performance Separators

Ceramic-coated Dry Process Ceramic Separators (SH) | *24µm, 29µm*

Our dry process polypropylene separators are also available with aluminum oxide ceramic coating to further enhance safety characteristics.

Thickness		24µm			24µm		
Product number		SH224D14	SH224D22	SH624D14	SH624Z14	SH229D14	SH229D22
Coating method		single side	double side	single side	single side	single side	double side
Porosity (%)		42±3	42±3	47±3	47±3	42±3	42±3
Thickness (µm)		24±2	24±2	24±2	24±2	29±2	29±2
Density (g/m^2)		17.1±3.0	17.1±3.5	16.8±3	16.9±3	19.8±3.0	19.8±3.5
Permeability (S/100ml)		340±70	340±70	250±100	260±90	400±100	400±100
Puncture strength (g)		≥280	≥280	≥220	≥320	≥360	≥360
Tensile strength (kgf/cm^2)	MD	≥850	≥850	≥900	≥1200	≥850	≥850
	TD	≥95	≥95	≥95	≥100	≥95	≥95
Shrinkage (%,90℃ 2h)	MD	≤2	≤2	≤2	≤2	≤2	≤2
	TD	≤1	≤1	≤1	≤1	≤1	≤1
Shrinkage (%,105℃ 1h)	MD	≤4	≤4	≤4	≤4	≤4	≤4
	TD	≤1	≤1	≤1	≤1	≤1	≤1

EXHIBIT K

TARGRAY

Battery Separators

PE & PP foam battery separators for lithium-ion battery manufacturers and R&D

Ceramic-coated Battery Separators for Li-ion Cell Manufacturers

One of the most critically important cell components to ensure cell safety is the separator, a thin porous membrane that physically separates the anode and cathode. The primary function of the separator is to prevent physical contact between the anode and cathode, while facilitating ion transport in the cell. The challenge with designing safe battery separators is the trade-off between mechanical robustness and porosity/transport properties.

Separators in most batteries are made of very simple plastic films that have the right pore size to allow ions to flow through while keeping the other components blocked. Designed to address the needs of lithium-ion cell manufacturers, Targray Polypropylene (PP), Polyethylene (PE), and ceramic-embedded battery separators deliver excellent porosity, as well as low cost, lightness and durability.

About Battery Separators

Separator Characteristics

Separator Requirements

Requirements for Battery Manufacturing

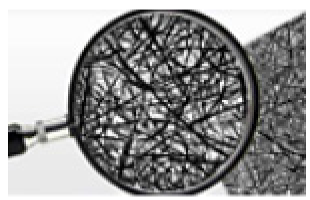
Battery separators are power-driven spacers that can be produced with fiberglass cloth or flexible plastic films made from nylon, polyethylene or polypropylene. The battery separator material must be absorbent and slim to allow the charged lithium ions to pass without obstruction, while occupying the least amount of space possible. Furthermore, battery separators must be able to withstand penetration and branching moss-like crystalline minerals in order to prevent the contamination of electrodes. If the separator material is compromised, the performance of the high-power cell declines.

Process	PE / PP Single or Double Layer Dry Method
Pros	Uniformity in thickness Strong chemical resistance High wet ability, high EL absorption High MD tensile strength Thermal shutdown easy control (PE) Low cost (PE) Environmental friendly process Low contamination in product Thicker separator possible Competitive quotation Flexibility tailor-made products

Process	PE / PP Single or Double Layer Dry Method
Cons	Lower TD tensile strength (PE) Lower puncture rate (PE)

Working closely with our supply partners and organizations including the Electrochemical Society and NAATBatt International, we help lithium-ion battery manufacturers and researchers worldwide commercialize ambitious new technologies for the energy storage market. Contact us today to learn more.

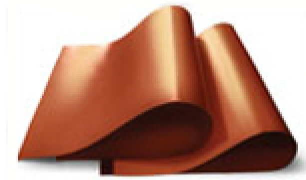
Related Products



PE and PP Separators

Our battery separator materials include PE and PP separators for battery technologies.

Privacy - Terms



Copper and Nickel Foils

Targray offers Copper and Nickel Anode Foils for energy storage technologies.

Ceramic Separators

Our fully ceramic battery separator solution is ideal for high-power battery applications.

+1 (514) 695-8095

To speak with a Targray representative.

Sign Up for Li-ion Battery Industry Alerts

Sign up to the Targray Li-ion Battery Newsletter for all the latest **lithium-ion battery** industry news and insights. Subscribers are also among the first to receive battery division product alerts and special announcements.

First Name

Last Name

Email

Submit

Solar PV Solutions

- Solar Financing
- Inventory Management
- Solar Silicon Materials
- Solar PV Modules
- Solar PV Cells
- Solar Wafers

Privacy - Terms

Battery Materials

- Electrolyte Solutions
- Separator Materials
- Battery Electrodes
- Battery Packaging
- Cathode Materials
- Graphite Materials

Biodiesel Solutions

- Wholesale Biodiesel
- Biodiesel Marketing
- EU Biodiesel Trading
- U.S. Distribution Network
- International Exports
- Blending Guide

Corporate Information

- Business Divisions
- Company History
- Company Awards
- Job Openings

- Latest News
- Articles & Insights

CIVIL COVER SHEET

The JS-CAND 44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. This form, approved in its original form by the Judicial Conference of the United States in September 1974, is required for the Clerk of Court to initiate the civil docket sheet. *(SEE INSTRUCTIONS ON NEXT PAGE OF THIS FORM.)*

I. (a) PLAINTIFFS

Celgard, LLC

(b) County of Residence of First Listed Plaintiff Mecklenburg County, NC
(EXCEPT IN U.S. PLAINTIFF CASES)

(c) Attorneys *(Firm Name, Address, and Telephone Number)*
Li Zhu
Robins Kaplan LLP, 2440 W El Camino Real, Suite 100, Mountain View, CA 94040, Tel.: (650) 784-4040
Robins Kaplan LLP, 399 Park Ave., Suite 3600, New York, NY 10022, Tel.: (212) 908-7400

DEFENDANTS

Shenzhen Senior Technology Material Co. Ltd. (US) Research Institute, AND Shenzhen Senior Technology Material Co. Ltd.

County of Residence of First Listed Defendant
(IN U.S. PLAINTIFF CASES ONLY)

NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED.

Attorneys *(If Known)*

II. BASIS OF JURISDICTION *(Place an "X" in One Box Only)*

- ☐ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question *(U.S. Government Not a Party)*
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity *(Indicate Citizenship of Parties in Item III)*

III. CITIZENSHIP OF PRINCIPAL PARTIES *(Place an "X" in One Box for Plaintiff and One Box for Defendant)*
(For Diversity Cases Only)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated *or* Principal Place of Business In This State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated *and* Principal Place of Business In Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

IV. NATURE OF SUIT *(Place an "X" in One Box Only)*

CONTRACT
- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment Of Veteran's Benefits
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excludes Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability
- ☐ 196 Franchise

REAL PROPERTY
- ☐ 210 Land Condemnation
- ☐ 220 Foreclosure
- ☐ 230 Rent Lease & Ejectment
- ☐ 240 Torts to Land
- ☐ 245 Tort Product Liability
- ☐ 290 All Other Real Property

TORTS

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury
- ☐ 362 Personal Injury -Medical Malpractice

PERSONAL INJURY
- ☐ 365 Personal Injury – Product Liability
- ☐ 367 Health Care/ Pharmaceutical Personal Injury Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

CIVIL RIGHTS
- ☐ 440 Other Civil Rights
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 445 Amer. w/Disabilities–Employment
- ☐ 446 Amer. w/Disabilities–Other
- ☐ 448 Education

PRISONER PETITIONS

HABEAS CORPUS
- ☐ 463 Alien Detainee
- ☐ 510 Motions to Vacate Sentence
- ☐ 530 General
- ☐ 535 Death Penalty

OTHER
- ☐ 540 Mandamus & Other
- ☐ 550 Civil Rights
- ☐ 555 Prison Condition
- ☐ 560 Civil Detainee– Conditions of Confinement

FORFEITURE/PENALTY
- ☐ 625 Drug Related Seizure of Property 21 USC § 881
- ☐ 690 Other

LABOR
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Management Relations
- ☐ 740 Railway Labor Act
- ☐ 751 Family and Medical Leave Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Employee Retirement Income Security Act

IMMIGRATION
- ☐ 462 Naturalization Application
- ☐ 465 Other Immigration Actions

BANKRUPTCY
- ☐ 422 Appeal 28 USC § 158
- ☐ 423 Withdrawal 28 USC § 157

PROPERTY RIGHTS
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 835 Patent─Abbreviated New Drug Application
- ☐ 840 Trademark

SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))

FEDERAL TAX SUITS
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS–Third Party 26 USC § 7609

OTHER STATUTES
- ☐ 375 False Claims Act
- ☐ 376 Qui Tam (31 USC § 3729(a))
- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced & Corrupt Organizations
- ☐ 480 Consumer Credit
- ☐ 485 Telephone Consumer Protection Act
- ☐ 490 Cable/Sat TV
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 890 Other Statutory Actions
- ☐ 891 Agricultural Acts
- ☐ 893 Environmental Matters
- ☐ 895 Freedom of Information Act
- ☐ 896 Arbitration
- ☐ 899 Administrative Procedure Act/Review or Appeal of Agency Decision
- ☐ 950 Constitutionality of State Statutes

V. ORIGIN *(Place an "X" in One Box Only)*

- ☒ 1 Original Proceeding
- ☐ 2 Removed from State Court
- ☐ 3 Remanded from Appellate Court
- ☐ 4 Reinstated or Reopened
- ☐ 5 Transferred from Another District *(specify)*
- ☐ 6 Multidistrict Litigation–Transfer
- ☐ 8 Multidistrict Litigation–Direct File

VI. CAUSE OF ACTION

Cite the U.S. Civil Statute under which you are filing **(Do not cite jurisdictional statutes unless diversity)**:
35 U.S.C. § 1 et. seq. and 18 U.S.C. § 1831 et. seq.

Brief description of cause:
This lawsuit concerns the infringement of Celgard's patents and the misappropriation of its trade secrets.

VII. REQUESTED IN COMPLAINT:

☐ CHECK IF THIS IS A **CLASS ACTION** UNDER RULE 23, Fed. R. Civ. P.

DEMAND $

CHECK YES only if demanded in complaint:
JURY DEMAND: ☒ Yes ☐ No

VIII. RELATED CASE(S), IF ANY *(See instructions)*:

JUDGE Virginia K. DeMarchi DOCKET NUMBER 5:18-cv-07441-VKD; 5:19-cv-02401-VKD

IX. DIVISIONAL ASSIGNMENT (Civil Local Rule 3-2)

(Place an "X" in One Box Only) ☐ **SAN FRANCISCO/OAKLAND** ☐ **SAN JOSE** ☐ **EUREKA-MCKINLEYVILLE**

DATE 09/16/2019 **SIGNATURE OF ATTORNEY OF RECORD** /s/ Li Zhu